

DISCOVERY

A Monthly Popular Journal of Knowledge

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Editorial Notes.

WHAT is there that cannot be included under the general heading of science? A short study of the daily time-table of the British Association leads one to believe that, directly or indirectly, nearly every aspect of our daily life can be classed under an appropriate scientific head. There is only one outstanding exception, art, and even this might creep in under cover of anthropology if it were old enough. It is unfortunate this divorce or rather judicial separation between art and science. One is conscious of it as an attitude of mind more associated with the mass than with the individual, but it is the individuals who express their views. The man of science tends to think the artist useless and out of date, and the artist looks upon science as malignantly utilitarian and therefore dangerous. He is inclined to go further and regard science not only as a danger to art, but a peril to civilisation. Both these attitudes are wrong, but to a greater or lesser degree they are the views held by otherwise intelligent people. They have a bias against the other side, and it is founded on mutual misapprehension. Science in its bearing on every aspect of life inevitably influences art, but does not necessarily endanger it. There is no need for hostility, for science no less than art depends on the same creative imagination. Both are disinterested and equally independent of uneducated opinion. A closer contact between these two extremes might well be of benefit to both, for the strain of hostility may be due more to ignorance of each other's points of view than reason. Some day, perhaps, there will

be a reunion between art and science probably through an extension of the field of psychology. It may provoke a revolution or a renaissance, which is only another way of saying the same thing from a different point of view, but it might have a good stimulating effect on thought in general.

* * * * *

The field of science as revealed by the time-table covers thirteen separate sections and a sub-section on forestry. The segregation of the latter suggests that the authorities did not like to see their sections sit down thirteen to a time-table. When you look into the subject matter disclosed by the titles of the papers you wonder how on earth they are able to classify some of the borderland subjects at all. The specialists have a number of extremely technical subjects to themselves, but the main purpose of the Association is not only to advance science, but to familiarise ordinary people with it and stimulate public interest in the work being done. To this end the popular lectures are the most important. The scientist is inclined to complain that the work of his kind is not properly appreciated by the world in general. There should be, he claims, more public support for science, for in the last resort science is dependent on public support and in return is in all its applications a public utility service. The mechanical fabric of our modern civilisation is built on physics, chemistry and engineering, and he feels that in return for benefits received, the world in general might pay up rather more in order to secure benefits to come. It is a sound claim, but a difficult matter to press until we educate the public to a realisation that science is not simply a matter of brainy and otherwise abnormal people pottering about in laboratories, disinterestedly discovering things, some of which may be useful or profitable. This fine old fiction is beloved of the business man. He likes the idea of the disinterested scientist. The unworldliness of the scientist is possibly a source of profit. It is a form of altruism he will applaud. That science pure or applied is a public utility service and should be properly and adequately supported is a new and

disconcerting idea to him. Nevertheless, it is a lesson the public must learn if the community is to make full use of their opportunities.

* * * * *

This is where propaganda is needed. The general public must be won from their conventional acceptance of science as something external to themselves and outside their lives, and brought to realise its enormous importance as an all-pervading factor in our lives to-day. The public interest is in those matters which immediately affect them. A popular paper on a new discovery in medicine or wireless holds their attention better than a learned contribution on the distribution or morphology of something with a Latin name. They would, however, be interested in the latter if it were explained to them how it in turn affected them by, let us say, contributing to the spread of foot-and-mouth disease or potato blight. If everybody reading a paper before their section of the Association had to explain in simple language the purpose of the work, why it was important or why it was interesting because it had a bearing on some particular problem, very few would fail to justify themselves. As it is, a paper of marked general interest may hide behind an awe-inspiring scientific title and fail to yield its secret to many members of the Association, let alone to the general public. All science can be made interesting if it can be made intelligible to the layman. Often it is not the content of a particular paper which can be treated in this way, but the layman would understand and appreciate the problem or the motive underlying the research if it were explained to him. The "why" is far more important than the "how," and explanation of the "why" is the best possible way of stimulating public interest in science in general. If every member of the Association could miraculously communicate something of his own interest and enthusiasm for some branch of knowledge to two or three members of the public a great missionary effort would be begun.

* * * * *

The scientific worker suffers not only from a lack of public support, but he has few channels of propaganda open to him. Year by year more space is being accorded to scientific work in the great daily papers, but there is a wide gap between the dailies, who are necessarily obliged to compress matter which should take columns into a six-line paragraph of news, and the official journals of learned societies which are read by the elect but not by the public. DISCOVERY is an attempt to bridge the gap between the two extremes, but DISCOVERY needs the practical help and support of scientific workers. We want them to help us by letting us know what they are doing and suggesting

interesting articles and topics. We want their help in another way too. We want them to help to get this journal into the hands of new readers. DISCOVERY may be looked upon as a missionary enterprise with a specialised purpose. We want you to help it by extending its range of utility and to look on it as a journal gradually developing a new intelligent public appreciative of the work of science and progress in all branches of knowledge. We want your help, your goodwill, and your encouragement in the enterprise.

* * * * *

The death of Mr. W. J. Bryan, mouthpiece of the Fundamentalists following the prosecution at Dayton, Tennessee, is something of a shock to those who were watching the development of the attack on intellectual freedom. It is not yet clear who will take his place, or whether legal eloquence will be substituted for the political spell binding. It will not do to assume that because Bryan is dead therefore the reactionary movement is quenched. Indeed, many competent observers are of the opinion that the loss of Bryan is almost an advantage to the Fundamentalists, and that the attack will now be even more dangerous, for it may not be so open. The real peril will in the end come not from the general moderate acceptance of evolution, understood inaccurately perhaps but yet understood, but from the extremists who will urge all kinds of peculiar and unsound or unproven tenets under the general banner of evolutionary thought. The fight is on, and it is adopting peculiar guises. "Science Leagues" and odd organisations are springing up and, if some of the propagandist literature which comes to this office is any index, the American citizen is going to have a hard time sorting out "what is evolution" from a mass of disreputable publications about sex and pamphlets devoted to social reorganisation on the Russian model. If the wisdom of the Old World is likely to be of service in solving the perplexities of our American cousins, the first thing to do is to clear the arena and keep the issue to the point. Is the evolutionary theory sound? Once we are led off into distractions about the "freedom of thought" we shall find ourselves in strange company.

* * * * *

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Migrations of Marine Animals through the Suez Canal.

By H. Munro Fox, M.A.

(Fellow of Gonville and Caius College).

Little by little some Oriental marine animals are invading the Mediterranean through the Suez Canal, and at the same time Mediterranean stalk may be passing through to the Indian Ocean. Some of the reasons why the interchange is so slow are expressed in the article, which raises points of great interest to zoologists.

In the autumn of last year a Cambridge University Expedition of four members was sent out to Egypt by Professor J. Stanley Gardiner, F.R.S., to collect all that could be found of the organisms living in the Suez Canal. The faunas of the Red Sea and Mediterranean are known to be very different from one another, and it is of extreme interest to the zoologist to know to what extent mixing is taking place through the artificial waterway across the Isthmus of Suez. Further there are most interesting problems as to why some marine animals can get through the canal while most of them cannot do so. But the interest does not end here. There is an additional complication in that certain marine creatures had crossed the isthmus before the present canal was opened in 1869, although not as Jules Verne suggested, through an underground passage! It is not very generally known that more than one Suez Canal existed in the time of the Pharaohs, and it must have been either by this route, or further back still in geological times, that the creatures in question passed across the desert.

Apparatus.

The Cambridge Expedition took with them numerous bottles of alcohol in which to preserve their catches, and all modern forms of scientific fishing gear. The dredge was largely used: Fig. 1 shows it being hauled in by a winch on the sailing boat. After the dredge came on board the catch was passed through sieves (Fig. 2) to sort out the smallest organisms. Worms living in mud were taken with a "grab" constructed of two steel jaws (Fig. 3). Further, the services of native fishermen were enlisted to catch fish. Fig. 4 illustrates the use of their peculiar "cast-net." The greater part of the life, however, was found on the

piles of piers and was scraped off as shown in Fig. 5. Naturally, in addition, physical data was collected of the temperature, density, oxygen content, acidity, etc., of the waters all along the canal. Fig. 6 illustrates the way in which a water sample is obtained from the bottom. After the bottle has been lowered the cork is jerked out by means of the line attached to it.

Let us turn now to the past history of the isthmus.

Napoleon's expedition to Egypt at the beginning of the last century has been one of the few military invasions in history that definitely contributed to science. He took with him a body of distinguished savants who studied Egypt from all points of view. What particularly concerns us here is that they collected certain marine forms of life at Suez which are similar to Mediterranean types but which are unlike

such as live in the Red Sea and Indian Ocean. There was a sea-anemone, two or three kinds of jelly-fish and numerous molluscs which came under this heading. We have now to consider by which of the two ways suggested above these animals had migrated south.

The nature of the desert soil of the Isthmus of Suez shows that in pre-historic (Quaternary) times the Mediterranean waters extended south of the present Port Said, and those of the Red Sea to the north of Suez. In the centre, between these two gulfs, was a freshwater lagoon into which flowed an arm of the Nile, an arm which no longer exists. There was thus a water connexion between the two seas, but its centre was fresh and this would naturally be an obstacle to the passage of marine animals.

Pharaoh's Canal.

The second former water connexion across the isthmus was an artificial one. It existed in historic



FIG. 1.
HAULING IN THE DREDGE.



FIG. 2.
SORTING THE CATCH IN SIEVES.

times, long after the Quaternary strait had become the dry land of the isthmus. This artificial connexion was formed by the Pharaonic canal. It presented the same freshwater obstacle but more accentuated. The history is this. The present Suez Canal, 100 miles long, has a lake on its course (see Fig. 7). In historical ancient Egyptian times this lake was the northern extension of the Gulf of Suez, and, indeed, it is probably across the extremity of this inlet that the Israelites crossed in their flight. Now in the 14th century B.C. the Pharaoh Seti I built a ship-canal from the head of this gulf to Bubastis, on the Pelusiac branch of the Nile Delta, an eastward branch which no longer exists (see Fig. 7). This, then, was the first artificial connexion between the Mediterranean and Red Sea. Ships could pass from one sea to the other via the canal and the delta. Marine animals might also have passed through, either under their own power or attached to ships' bottoms. But as already pointed out, they would risk death in the freshwater.

Seti's canal fell into decay and at the same time the northern extension of the

Gulf of Suez gradually silted up. Finally it dried completely and all the sea-salt crystallized out. When de Lesseps constructed the present canal the sea-water was let into this ancient basin which forms the present-day lake referred to above. The salt-deposits on its floor make the water in the lake of much greater salinity than the sea, hence the name of Bitter Lake.

Salt Lake Barrier.

To return to the Pharaohs, the ancient canal was opened again by Darius the Persian in the 6th century B.C., and again in the 3rd century by Ptolemy II, who continued it past the silted-up sea arm to the site of the present Suez. He founded the city of Arsinoë there. By Cleopatra's time, however, the canal was again impassable, but the Mohammedan Arab conquerors of Egypt re-opened it in the 7th century A.D. A hundred years later it was finally closed for strategic reasons by the Calif Mansur, the founder of Baghdad.

So much then for former water connexions across the isthmus. From our standpoint their chief interest is the freshwater barrier to migrations which they presented. Be this however as it may, some migrations did actually take place, as Napoleon's savants found, in spite of the difficulty. Now, to-day, the barrier is of an opposite nature; it is the great salt content of the Bitter Lake. In this connexion it is interesting to make a prophecy. At the present rate of solution of the salt on the lake bottom all will have disappeared

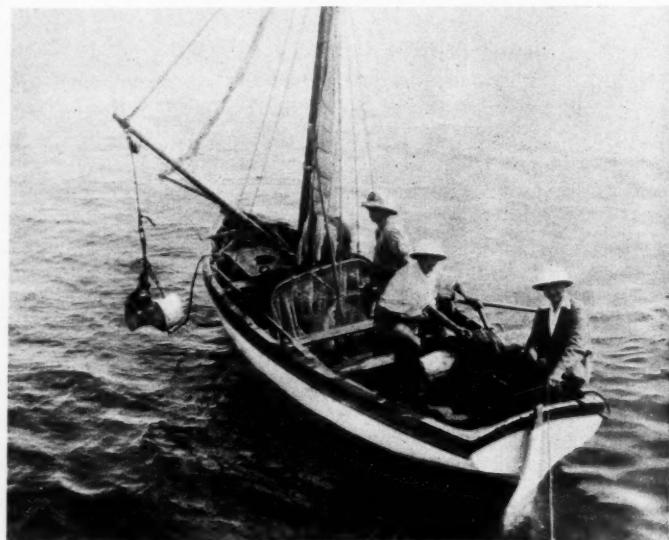


FIG. 3.
THE GRAB AT WORK.



FIG. 4.
EGYPTIAN FISHERMAN USING A CAST-NET.

by the year A.D. 2050, and another Cambridge Expedition should then be sent out to see what changes in the canal fauna result !

Distributing Ships.

The other principal obstacle to migration must be the narrowness of the canal—its average breadth at the surface is 150 yards—so that the big ships' wash disturbs fixed and creeping forms on the banks and bottom. The floor, too, is continuously being turned over by dredgers. Favouring the passage of organisms, on the other hand, are the ships' bottoms to which they may attach themselves, and the currents. The Expedition particularly studied the faunas of ships' hulls. As to the currents, none seem to be directly due to a difference in level of the two seas at the ends of the canal. This difference is very small, the average level of the Red Sea being ten inches only above that of the Mediterranean. There are, however, rapid tidal currents from Suez to the Bitter Lake, changing in direction twice daily with the flow and ebb. These must sweep small floating life and larvæ up as far as the lake. In the northern stretch there are no tidal currents—the Mediterranean is well known to be almost tideless—but there is a slow constant streaming. This is to the north for ten months of the year and to the south in August and September. The northward migration, of small animals at any rate, should thus be most favoured.

The principal results of the present Expedition relate, as might be expected, to the Bitter Lake, both to its influence on the migrations and to its own fauna, for it is a unique case of an arm of the sea having a higher salt content than the sea itself. Many other lakes saltier than the sea are known, but they are always land-locked and so not open to immigration.

A Surprise.

The nature of the Bitter Lake fauna turned out to be most surprising from two different aspects. In the first place we had anticipated finding an impoverished fauna in an unfavourable environment. On the contrary, and to our great surprise, we discovered a fauna of sponges, sea-anemones, star-fish, worms, and so on, much richer than in the Gulf of Suez or in the Mediterranean at Port Said. The

temperature was the same as in the seas, so this is not a cause. The reason may be a more favourable bottom or actually the greater salt content itself. In support of the latter suggestion we found richer pier-growths as far north as the current takes the saltier water during ten months of the year.

This was the first surprising thing about the Bitter Lake. The second was the size of the shell-fish and fish. Crabs and soles, far from being stunted, are as large there as in the sea, and grey mullet grow to a greater size in the Bitter Lake than they ever attain in the Mediterranean, whence they come. There is a very common black worm-like creature (*Synapta*)

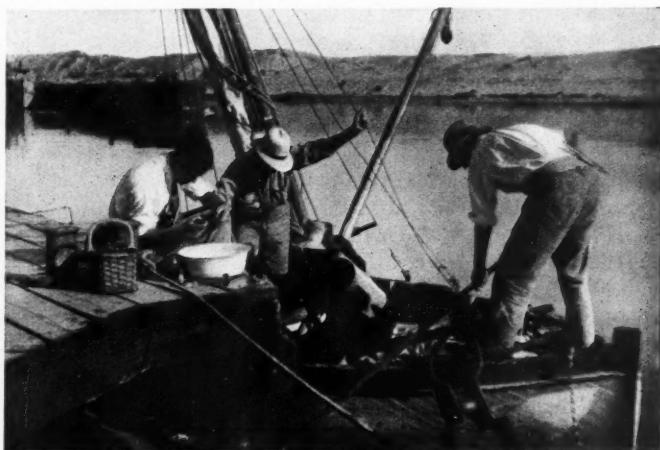


FIG. 5.
SCRAPING THE PILES OF A PIER FOR SPECIMENS.

which is ten inches long at Suez and eighteen inches in the lake.

Another important result of the expedition's work is that there are remarkable changes in the fauna of to-day as compared with what it was thirteen years after the opening of the canal. This comparison is

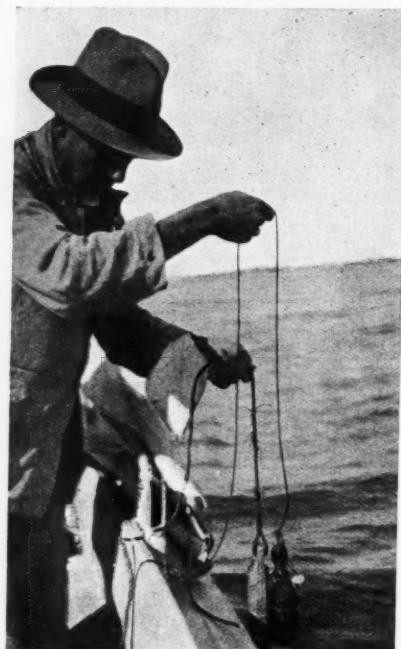


FIG. 6.
LOWERINg A WATER SAMPLE BOTTLE.

possible because in 1882 a Swiss zoologist collected all the animals he could find in the Suez Canal. In 1882 there were found no sea-anemones or starfish at all, there were few worms, only one crab, and two sponges. To-day all these groups of animals are abundantly represented by numerous species. This difference is most striking. It is not that during the first thirteen years insufficient time had elapsed to allow of immigration. Such cannot be the case, for at the end of one year after the canal was opened molluscs were abundant in its central region. The density of the Bitter Lake was higher formerly than it is to-day—that may be a cause—or possibly a difference in the proportions of the salts, for the most soluble kinds would dissolve first from the floor of the lake. Precise data on these points will be available when we have had time to analyse the water samples brought home.

It may be, however, that the late peopling of the water commenced with the widening and deepening

of the canal which was undertaken in 1886 and terminated in 1896. At all events, it is striking that the only instance where we are able to fix for certain the dates of first migration of an animal through the canal, these dates fall in the period 1886-1896. The animal in question is a swimming crab. Since it is fished for food and sold in the markets in Egypt, records exist of its first appearance at stations along the canal. The crab has always been common at Suez, but it did not invade the Bitter Lake until 1889. Each successive year it was fished at a point further to the north until finally, in 1898, it reached Port Said. To-day it has spread to right and to left along the Mediterranean coasts, being caught for sale at Haifa in Palestine and at Alexandria. Incidentally this is not the only example of an animal of commercial value that has passed through the canal. The pearl oyster, from the south, is now found at Tunis. Perhaps some day it will be found there in sufficient numbers to start a pearl fishery, although before that time doubtless the artificial pearl will have completely ousted the natural one !

The Latest Factor.

However, to return to the alterations in the canal fauna, a change in the opposite direction was also noted. Formerly mussels and a boring mollusc (in the literal sense) were extremely common in the centre of the canal. To-day we found them to be absent. Once more the cause is obscure, but a factor may be



the advent of oil tankers. Mussels which formerly were common in Barrow docks have vanished since oil ships arrived.

Such, then, are the main conclusions drawn from the work of the expedition, but much more valuable information will be available after the specialists, who are now naming the collections, have finished their work.

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The Elementary Geography of the Air.

By O. J. R. Howarth.

Most of the accepted meteorological teaching in the geography textbooks is wrong and out of date. It is time that educationalists realized the results of modern meteorological research.

GEOGRAPHY, in its development of recent years as an educational subject, touches the fringe of many other subjects. This feature has been pointed out alternatively as a virtue and a defect: a virtue, because geography ought to stimulate the pupil's interest in a wide range of knowledge, and to guide him in the choice of specialization when the time comes for that; a defect, because the geography lesson (it is said) has a habit of rambling off into topics with which it is not directly concerned, and therewith of purveying information which is either misleading owing to generalization or actually incorrect in fact. The virtue, with good teaching, should, and does, far outweigh the defect; but a question constantly present to the teacher is how far to pursue any of the kindred subjects—how far the time at disposal for the geography lesson, and how far the accepted facts, without involving argument clearly beyond the scope of the geography lesson, allow any such subjects to be pursued. There is the further difficulty that some of these kindred subjects, admirable and intensely interesting as they may be made for educational purposes, would appear in the curriculum hardly or not at all, unless the geography lesson served as their vehicle. Of such are meteorology and climatology.

Accurate Forecasts.

A substantial proportion of persons in this country who read the weather forecasts in the daily papers, probably still do so with a certain tolerant belief that the forecaster is just as, or more than, likely to be wrong. This is not the case; and the forecaster has long been a silent sufferer under the almost complete public ignorance of his methods, data, and difficulties, and of the very elements of the climatological knowledge upon which his work is based. But the proportion of his readers upon whom these strictures are passed is smaller than it used to be. In part this is due to the obviously increased efficiency—one might dare to write attractiveness—of the forecasts themselves, their better adaptation to public needs, and the general sense of stronger definition and greater certainty which of recent years they have come to afford. The forecaster in this country must (for example) know where he stands a great deal better in these days, when he can receive wireless weather reports from ships far out on the Atlantic, than he did when he knew nothing of what was coming to him

from that direction beyond what the cable from Valencia could tell him. For the rest, the present generation has a better chance of following these developments with understanding than its fathers had. To a limited extent the elements of weather observation have found their way into school curricula. To a much wider extent the relations of the broad facts of world climate and the leading regional features of weather, especially in their bearing upon the life and occupations of mankind, have come to form one of the foundation-stones of the geography lesson.

The Time Factor.

The difficulty in the way of carrying on meteorological observation in schools is largely one of time; but if time allows there can be no doubt of the interest and value of rain gauges and screened thermometers; the (mercury) barometer; perhaps even the minimum thermometer for temperatures on grass, the sunshine recorder, the nephoscope and so forth. Rainfall and other observations taken at schools, however accurate, have, of course, no value for official records unless maintained in holiday time as well as term; a few are so maintained. But apart from this, observing by pupils who take any interest in the matter must aid the understanding of the generalizations upon which their study of climate in the geography lesson—the geography of the air—is based. There need be no confusion of issues. At a conference last year between representative bodies of meteorologists and teachers, one of the second group suggested that few meteorologists were climatologists, but this view seems hardly worth argument, and was received with surprise by the distinguished exponent of both branches who occupied the chair.

But whether with the aid of observation or not, the teacher of geography has to inculcate into his form some climatic facts, and here he may encounter various difficulties. It is arguable that at any rate up to school certificate standard the whole subject of geography is so big and diffuse, and the time generally allowed for it so short, that except as bearing upon human activity there should be no attempt to study cause and effect. The direct climatic effects upon man, it is urged, are exerted by temperature, winds, and rainfall. Therefore, the distribution and effects of these alone should be taught; it suffices, on this theory, for the geographer to know something of seasonal and diurnal ranges of temperature, of prevalent winds, of annual and

seasonal incidence of rain and snow, as reasons why men do certain things, why certain plants grow in certain regions, but he need seek no reasons why the climatic phenomena themselves occur when and where they do.

It will not work. At least, it is hard to imagine, given a teacher with any sort of interest in the subject, and confronted with an intelligent and inquiring pupil, that either of them would be satisfied with that kind of thing. The time-table may compel it; the candidate may pass the certificate examination after a course so restricted, but the geography lesson has then failed of the high object assigned to it in the opening paragraph of "these presents."

But if this is a fair argument, it behoves the geography teacher to work in hand with the investigator in meteorology. Meteorological research has advanced far of recent years, and has in some measure resulted in the research-worker realizing how little he knows. A distinguished geographer, no longer with us, observed once to the writer that the meteorologists had cast down a number of his idols, and had set nothing in their places. But these places are being filled, or at least evidence is adduced that they ought to be empty. Nevertheless, the old gods die hard, and it cannot be doubted that as regards causes of certain climatic phenomena there are things still said in geographical textbooks which ought not to be said.

The New Ideas.

For example, the old supposed cause of depressions in temperate latitudes is still with us in the books. Like other such explanations it has the merit of simplicity. That a depression should consist of a circulation of the air set up around a centre of warm, moist, and so relatively light and rising air, is an easily intelligible idea; but it has been disproved. The favourite comparison of a temperate depression with a tropical whirlwind on a widely extended scale must go. "We are able to say quite definitely," writes Sir Napier Shaw, "that the general motion of air in a cyclone outside the tropics is different from that of a whirlwind; the ascertained motion of the centre on a map is the direct consequence of the motion of the air in the cyclone itself and part of it; it is not the general motion of the current in which the whirl is contained." The complicated motion of the air in a depression as now understood by the meteorologist is not part of the necessary equipment of a geography class. And if any pupil asks what is the cause of a depression, he can only be told that there are various ideas, none proven. Again, it is possible to describe in words the types of weather experienced by an observer, say, in this country, as a depression as some part of one passes over the place of observation,

but the beloved old diagram illustrating this in some of the books is too inaccurate to rely upon, and should be expunged. As for the behaviour of winds in relation to a depression or an anticyclone, there is before us a textbook of physical geography, dated 1922, which states that winds blow from regions of greater pressure to those of less, and leaves the matter at that. This seems hardly fair to the teacher, who is confronted with the necessity of explaining maps showing winds blowing nearly parallel with isobars. "Then," the apostles of simplification would say, "leave out the isobars, drop your depressions and anticyclones, be content with the fact that our prevalent winds are south-westerlies." It will not work, unless the devil drives in the guise of time. But the books do not commonly offer a simple idea of the directing forces at work upon the surface winds—the pressure gradient, the law of deviation, the curvature and relief of the earth's surface. Again, the anticyclone is not uncommonly described in the geography books as produced by a descending spiral eddy, or words to that effect. The "Meteorological Glossary" (Meteorological Office, 1918) defines it as a region in which pressure is high relatively to its surroundings, and states that its causes are unknown. Plenty more examples might be adduced; here is a simple one to end this list—

"Fog is a cloud in the lower air." (From the "text-book of physical geography, 1922," previously cited).

"Mists and fogs are similar in many respects to clouds, but there is one fundamental difference which makes it very undesirable to describe them as 'clouds near the ground.'" This is from Mr. W. H. Pick's "Short Course in Elementary Meteorology" (Meteorological Office, 1921), which goes on to show how clouds generally follow upon pressure changes, while mists and fogs are due to radiation from the ground.

Remedy Wanted.

One imagines the geography teacher's comments at this stage. "This is all very well," he might say, "but how and why should I be expected to keep up-to-date with this very inexact branch of scientific research, along with a dozen other similar preoccupations, especially on the economic side, which are just as closely the concern of my subject, if not more so?" It appears to the writer to be a clear case for assistance by one or more of the scientific or educational associations through the medium of their journals, making systematic (not spasmodic) efforts to keep geography up-to-date in *all* departments. There used to exist (and may still exist) a periodical called "The Geography Teacher's First Aid," or some such candid title. It was, we believe, a modest private venture, but the right idea was present in it.

Cinema and Ethnology.

By M. W. Hilton-Simpson and J. A. Haeseler.

There are two sides to field work with a cinema, one the purely scientific side, the other the showman's. Success in both fields demands a realisation of the needs of each, a thorough grasp of technique and a spirit of compromise.

THE Editor of DISCOVERY has asked me for an article which "might prove interesting to a large number of people who have vaguely considered taking a cinema camera on an expedition," for the forming of ethnological records. Ever since I commenced field-work as an ethnologist, more than twenty years ago, I have been in that position myself. I knew the value of such records, a value too obvious for emphasis here, but I realized that my knowledge of photography was that of a "button presser," and somehow I never thought seriously enough of the subject to learn even the rudiments of cinematography.

Records.

In 1923, however, an opportunity arose for me to see the cinema in action in the ethnological field. I met Mr. J. A. Haeseler, an anthropologist of Harvard and Oxford Universities.

He was about to commence the production of a "library" of films illustrating the manners and customs, arts and crafts of foreign peoples for use in teaching history, geography and anthropology in Europe and America.

It was decided that he should accompany my wife and myself upon our sixth visit to the Shawiya (Berber) tribes of the Aures *massif*, in S.E. Algeria, in the winter of 1923-24. I was to organize the expedition and, with my wife's help among her Shawiya women friends, to endeavour to persuade the natives to submit to the camera. The photography, in which he had been most carefully trained, was to be entirely in Haeseler's hands.

This single journey, in the course of which I never once used the cinema camera myself, constitutes my total experience of that camera in the "field."

Nevertheless, first impressions are sometimes almost as useful to beginners as those of experts whose familiarity with a subject has bred contempt for its initial difficulties. I had a very good chance of seeing these difficulties which obstruct the way of the cinema photographer among primitive peoples; I have enjoyed

the advantages of his results in the lecture hall.

As to the purely technical side of the photography, I have asked Haeseler himself to furnish us with some notes from his now great experience. This he has consented to do, despite the fact that he is now most busily occupied with film technique in preparation for further work in the field.

(*Ordinary hand camera negative by Hilton Simpson.*

FILMING THE VERTICAL HAND LOOM.

My wife and I preceded Haeseler to Algeria, repairing to one of the larger villages of the Aures hills, in which we had been personally acquainted with most of the natives for the last dozen years.

Smoothing the Way.

In the course of our normal ethnological inquiries we let drop that we were expecting the arrival of a friend who would take some photos with a camera superior to my own, with which latter they were already acquainted. As we anticipated, no objection was raised to this by our Shawiya friends, and we returned to our railhead to meet Haeseler with the certain knowledge that we could, at any rate, commence our work on such women's crafts as pottery making,



weaving, etc., as well as on the occupations of the men. When he arrived I must confess that I was astonished at the amount of his impedimenta. The size and weight of his tripod particularly appalled me !

I had only considered the matter so very vaguely that I had not realized the necessity of strength and weight in a tripod that is to hold a heavy camera absolutely rigid in any position and in a gale of wind.

However, pack mules were, I knew, fairly easily obtainable in the districts we intended to visit, so the amount of kit mattered little. Nevertheless, it was apparent that the question of transport in a rough country is one that must be fairly faced before departure by anyone proposing to use a full-sized, fragile cinema camera in the field.

Transport Troubles.

For example, two trusty natives will probably be required to carry the camera, tripod and films when in constant use, to say nothing of the conveyance of the whole outfit on the line of march. Haeseler spent a few days in taking practice shots, to test the Algerian light, before we left our base for the mountains. It was then that I learned the truth of a remark he had made that the work bore little resemblance to the taking of snapshots.

The extreme accuracy required to obtain the exact range in "close up" photos, the vigilance necessary to prevent curious spectators casting their shadows on the picture from flank or rear during the taking of a protracted scene; the constant anxiety lest the "targets" may become weary and remove themselves before a shot is complete, are but a few of the minor worries which vex the soul of the cinema photographer.

The work is most assuredly a whole-time occupation. I think the success of Haeseler's films is largely due to the diligence with which he developed "test" fragments in a tank developer to observe the effect of the apertures he used in various conditions of light. This task frequently occupied him well into the night, allowing him to snatch but little rest before commencing his next day's work, often shortly after dawn.

When once we got to work in the Aures I was much struck by the useful pictures he obtained in the interior of gloomy huts in which I should have believed cinema work to be impossible. I remember on one occasion we passed the door of a hut in which we had been invited by the owner to take photos whenever we pleased. Haeseler, wishing to make a test of light in an interior, glanced in and hastily beckoned me to follow. On the floor, in one of the least dark corners of the room, lay the lady of the house—asleep, with

two small goats beside her. Scarcely a target for the scientific ethnologist, perhaps, but one which aroused in Haeseler the instincts of the stalker ! The scene was recorded on the cinema—it subsequently yielded an excellent print—and the apparatus removed from the hut before the lady awoke !

Apart from showing the uses of a good camera in a bad light, this incident shows how the cinema can be employed to take scenes unbeknown to the native. This, of course, is particularly the case where the telephoto lens is used.

Nevertheless, "surprise tactics" and "ambushes," if discovered, may well lead to resentment and sulkiness and so prevent the taking of better pictures later on. In any event, such tactics are out of the question when really complete series of photos of such processes as weaving are required. The very close-up views needed to show the finger-work on the hand-loom preclude all hope of secrecy. Such pictures can only be taken with the knowledge and consent of the native, and they cause the photographer to be even more of a slave to native caprice than the ethnologist must necessarily be.

Our method of obtaining scenes of such arts and crafts was to approach, say, some friendly woman and ask her to let us know when she proposed to make a batch of pottery for her own use so that we might come and take our photos. In this way we were able to get the entire process, from the digging of the earth to the finished pot, without one single item in the series being "got up for show." The utter lack of self-consciousness in face of the camera among the Shawiya of both sexes astounded me. They went about their daily tasks as if there were no photographers within miles of them. Even the young girls seemed

Avoid Arrangements.

born to the profession of a cinema "star." But the very complacency of the Shawiya places a pitfall in the path of the photographer. With willing helpers round him, he is apt to be tempted to "arrange" various ceremonies, etc., which are not being performed in earnest at the time of his visit. We sternly set our faces against recording anything which was not being done by the natives *for themselves*. Nevertheless, the temptation was strong.

I much desired a record of the ceremony of carrying a bride to her husband's home. No weddings took place during our stay in the hills. What easier than to "arrange" the scene required ? But emphatically *no*. The natives, performing the ceremony in a half-hearted spirit would probably omit some small demon-scaring act ; despite my fairly complete

knowledge of the matter I should, equally probably, fail to notice the omission. The result would have been that we be branded as liars by the first scientist who observed the error on our film at home.

Time Factors.

I shall never cease to rejoice that, in respect of these temptations, we kept our virtue intact, and we secured a very full programme none the less. I soon discovered that the taking of even so straightforward a craft as pottery-making was not quite so simple a process as I had supposed. It takes, say, half-an hour to produce a hand-made pot, exclusive of the firing. At any rate, it takes so long that to keep the camera in action all the time would be ruinous in film and too long for exhibition purposes. Therefore a few feet only must be taken of every stage in the work—applying the side of the vessel to its base, fashioning, polishing, decorating, firing, etc. A complete review of the craft can thus be shown on the screen in a few minutes. But this implies a good previous knowledge of the craft on the part of the photographer or a companion.

We found it an excellent plan, when once the camera had been mounted, for the photographer to attend entirely to his apparatus and for his companion (knowing the craft to be photoed), to occupy himself with the native's work and warn the photographer of any impending change of process which would require to be recorded.

I believe it is extremely difficult for the photographer to carry out both tasks himself when dealing with the technology of a craft. General pictures of the scenery not requiring such careful observation could, I should say, be taken as well by one man alone. If I had to record, single-handed, the arts and crafts of a primitive people on the cinema, I think I should

devote quite the first three parts of my time to a detailed study of each craft before I brought the camera into action at all for that particular craft. In this way I should hope to eliminate much wastage of film.

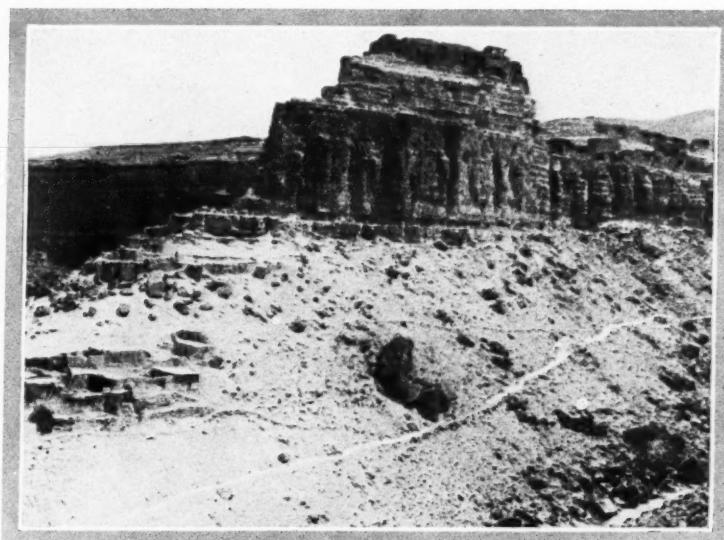
When once the trip has come to an end and the photographer has returned to civilization, his task is by no means over. Haeseler, I know, burned the mid-night oil for many weeks editing the films. The very titling of a print (so that it could be shown without an accompanying discourse) was a long and laborious job. But at last he had the satisfaction of hearing experts at the Royal Geographical Society refer to "the amazing excellence" of his films. (*Geographical Journal*. Vol. LXV, p. 30).

From the comments passed by scientists at the various learned Societies to which we have shown the pictures, it is evident that records of this kind are of great value to anthropologists at home. That they are popular we were convinced by the crowded halls in which we lectured in Paris, Brussels, and Antwerp. This popularity, I am convinced,

is not to be found among the highly educated alone. When rehearsing my lectures in the picture theatre of a small country town I invited persons of all classes, of all ages, and of every degree of education to witness the films, in small parties at a time. I found that one and all were intensely interested in them, those educated in our national schools not less so than those with high university degrees.

Educational Values.

It does seem to me that a collection of such records of native life and industry as Haeseler obtained in the Aures, in addition to its obvious value to serious students of anthropology, could be made into a most powerful educational instrument for use in schools,



DEFENSIBLE VILLAGE, TYPICAL OF THE SOUTHERN SLOPES OF THE AURES RANGE.
(Enlarged from cinema negative by J. A. Haeseler.)

and I trust his "library" of films, when completed, may go far towards the brightening of education and the dissemination of a better knowledge of distant lands. Any other cinema records made with the same care and accuracy by other scientific workers would help immeasurably toward that end.

NOTES BY J. A. HAESELER.

Though the cinema will give incomparable records of the life of a foreign people, it exacts a stiff price for its results. Assuredly the taking of a cinema camera on an expedition is not to be lightly considered. With its equipment it is so bulky that, unless it is to form one of the major parts of the expedition's work and to fill a large place in the expedition's plans, it might quite as well be left at home so far as any worthy results are concerned. During the time the cinema work is going on it is, at least, one man's job to handle the camera. Before each time the camera is brought into action at least seven or eight adjustments must be made. No matter where in the world one sets up a cinema camera, one becomes a centre of interest and attracts a crowd that soon runs into scores. Managing these is a task for two or three vociferous native assistants, and on market days or during ceremonies the conditions are particularly trying.

The people doing the things that are being recorded must not be distracted, and must be kept at whatever they are doing within the field of view of the camera. When the actual photography is finished, the work is but half over, for the care of the camera, the loading of the magazines, and the packing of the film are exacting jobs, as is the development of test strips. So, unless the time an expedition is to be in the field is extended by at least one-third, it is better to have someone who can give his entire attention to photography.

Professional Psychology.

If this is to be the case, then there is a problem before the leader of the expedition. It is very difficult to get the ordinary cinema camera man to fit himself into the scientific spirit of an expedition. His is a different *milieu*—that of a showman—and it is from this point of view that he is inclined to regard everything that presents itself. Consequently, unless he is ruled with a rod of iron, told exactly what to take and almost where to place his camera, his results from a scientific point of view will be deficient. And to give a camera man as strict orders as this, when he is used to considerable independence, is not apt to keep the members of the expedition in good humour. On the other hand, a scientist with a good knowledge

of ordinary photography could pick up cinematography in a few weeks and, if a complete outfit was turned over to him for practice purposes some time before the expedition, he should be able, with the advice of the company selling the camera and the cinema laboratories, to make himself proficient enough to carry out the work.

Technical Necessities.

If time is no object, then an ethnologist going into the field single-handed might do much good work with native assistants. In any case, a thorough study of a craft or custom must first be made. It is one thing to go into the field with someone like Captain Hilton-Simpson, who has made a painstaking and detailed study of the habits and industries of a people, and another to take a cinema camera into an unworked field. In this case the making of the cinema record should come only after a complete study of each phase of native life. The films in themselves may save a great amount of note taking, for they are, in themselves, unparalleled notes. But skeleton notes as to the order of parts of a ceremony or a craft should in any case be kept, for the order of these is not always apparent from the film, and the scenes will have too much risk of becoming mixed up in the editing.

If the expedition is to be in the field a year or two it is well to make arrangements to ship the exposed film back every three or four months at least, and to receive fresh supplies of negatives from home. Cinema negative keeps well, and with good care stands a half year's travelling without difficulty. Kodaks will supply negative in four hundred foot lengths in a tin box with a corrugated paper soldered inside another tin box. In this way it is almost weather-proof and, if resoldered in a fairly dry climate, it should stand any travelling.

This company will also furnish a standard cinema developer for tank development at fixed temperature and time rate. With this, tests of several pieces of film, a few inches in length, can be made in the field and the exposure checked. Cinema film is supplied in such great lengths that it is extremely difficult to handle for developing all of it in the field, and for anything but tropical photography, it is more practical to send it back to a commercial cinema laboratory for development. In the case of tropical photography the practice is not yet fixed so far as I have been able to learn but, since development in the field would double or treble the work of making film records, it is to be avoided if possible.

While on an expedition a large light-tight changing bag can be used for transferring the film from the

boxes to the magazines, for putting the test strips in the tank, etc. In this way no darkroom is required. It must not be supposed, however, that cinematography eliminates the need for other photography on an expedition. The picture on the cinema film is only one inch by three-quarters in size, so that enlargements show considerable grain and loss of detail and tones.

Still Camera Needed.

It is better not to count on the cinema for ordinary photographs, but to record also every phase of native life and craft with a camera which is large enough to give a good enlargement, a quarter-plate for example. If mishaps occur with some of these negatives enlargements from those of the cinema can be used to replace them, but it is not advisable, if good results are desired, to place much dependence upon them.

For close-up views, such as the hands at work, they are quite all right, but even then it would probably be less bother in the long run to make a full set of the still pictures. As for choosing a particular picture from a cinema film for a certain significant action, this is difficult, because the films are not

usually taken at a fast enough speed to stop the motion (and eliminate any blur on the negative), and it either means cutting a piece from the negative at that point or making a duplicate negative, both of which one does not generally care to do. It is needless to say that the making of a complete set of still photos greatly increases the work of the photographer of an expedition. When one returns from an expedition one has still a great part of his work before one. My own practice is to sort my negatives after they have been developed. All the scenes of a particular craft or ceremony are put together and as nearly as possible in order. Then those scenes of a phase of the native's life, such as the women carrying water in goatskins to their houses or their modes of transport or their work in the gardens,

which I have probably taken on different days, I put together. The scenes run into hundreds, and for each of these I write out a small card with a short description of the scene which will identify it in my mind. Then I obtain a positive non-flam print. This print I go over scene by scene, projecting each one perhaps several times, cutting it where the significant action begins and where it ends, choosing between it and other similar pieces, and putting it in a logical order in its small group which later finds its place in the film as a whole. After all the several hundred scenes have been put in their proper order I write the titles, which are then photographed on film and inserted between the scenes. When the working print has been prepared in this way it can be

turned over to a girl in the laboratory, and she can put the negative in the same order and cut it in the same way. Commercial laboratories have rooms they rent where all of the above work can be done. It can be readily seen, however, that for scientific presentation, this editing should not be entrusted to a man who is not a scientist. The

ordinary cinema camera man is almost sure to cut the scenes so short that one gets but a little glimpse of them on the screen. As for the general presentation, the choosing of the scenes, their editing, and the writing of the title, this requires a general background and knowledge that is not the common possession of the camera man.

4,000 Feet an Hour.

The length to which cinema films run is generally quite appalling to the layman. For an hour's scientific lecture, and when the film is projected at the pace which shows how the people normally move and work, nearly four thousand feet of film are required. And to get this four thousand feet one should allow oneself at least six thousand feet of negative for the field,



(Enlarged from cinema negative by J. A. Haeseler.
HOUSES DEVELOPED FROM CAVE DWELLINGS IN THE AURES.

provided one is very economical and makes a thorough study of every craft and custom before photographing it. There will be scenes one will want to choose between, and there will be something to be cut off the beginning or end of most of them, so that even this is hardly a comfortable allowance. If the picture is titled, the titles take up a fifth of the length, and consequently allow for more wastage.

Points on Projectors.

I said that I had my working copy made on *non-inflammable* material, for it may probably be used for lecture purposes in the future and, whereas it is illegal to project the ordinary celluloid film nearly everywhere in England without a projecting box, the film with the acetate of cellulose base is not limited by such irksome restrictions and can be quite generally used. The problem of projection machines is not the least that the scientist using the cinema must anticipate. Though a film can ordinarily be projected a couple of hundred times from clean professional machines, scientific societies are sometimes none too careful in the equipment they provide for a lecturer, and a print of a film (costing about £25 for an hour's lecture) can be ruined for practical purposes by being run once through a dirty cheap projecting machine. The best way out of this difficulty is for the lecturer to purchase a portable projection machine (made in the form of a suit case) which he can get for approximately £50, and to use this for all his lectures, except where societies furnish him with a first-rate professional projecting machine. Societies can usually find operators locally who will come in for an evening. It is best in all cases where possible to have a projecting box, for the noise of the projecting machines often drowns the voice of the lecturer, although this is not quite so bad if he uses a portable projector.

Small-sized and cheap cinema cameras are still of little use except for home amusement and, since the cinema camera in the field is such a serious affair, it is hardly worth while bothering with undersized or cheap equipment. A full-sized, reliable professional cinema camera costs about three hundred pounds in England, and something less than two hundred in France. One would do well to have three lenses, a thirty-five, fifty, and seventy-five millimeter, though one could generally do without the latter, and possibly one of a hundred might be better in its place. A wide angle lens, such as a thirty-five millimeter, is very useful in working at close quarters and in crowds. A telephoto is of little use in photographing peoples, for their case is different from that of animals. I have not found my six-inch

lens worth its investment, for example, but a wide aperture lens (the good cinema lens has a 3.5 aperture) such as is made by Dallmeyer, might be useful in taking interiors and poorly lighted scenes. Also reflectors made of wood and covered with silver paper would be helpful additions to an equipment, but they are very bothersome. Slow motion pictures require a special camera which is very expensive, and they are consequently out of the range of the ethnologist. The cost of operating the cinema is great because of the length of film required. Cinema negative can be secured from Kodaks for about 2d. the foot. Developing and making the first print costs together between 2d. and 3d. the foot. From these figures it is possible to come to an estimate of the cost of a cinema on an expedition. If the scientist cares to look beyond the scientific field, with the hope of getting a return on his expenditure, there are a number of commercial cinema companies that buy rights to travel material. There are those who put out magazine reels made up of several subjects, those distributing single-reel subjects, and those exploiting travel feature films. Probably one or the other of these could use material the scientist could get with a little additional trouble, and it might be well to consult them beforehand. Their needs and demands should be kept entirely separate from his scientific films, and the photographer would be well advised to make separate negatives for the material he considers suitable for them. After negatives have run through printing machines several scores of times for theatrical distribution they are inevitably somewhat scratched, and their usefulness as scientific records perhaps lessened.

Separate Studies.

In other words he would do well to make out a programme for his scientific film and another for those that are to be theatrically distributed, and keep the two programmes and films entirely separate. This will mean considerable trouble in retaking a good many scenes and keeping additional records, and it would mean additional expense, but the photographer should get returns that might help to defray his cinema costs.

HOW BLOOD BREATHES.

By an unfortunate printer's error the captions of the two blocks illustrating Dr. Eric Ponder's article were transposed. The error was doubtless obvious to most readers, but the legend beneath the Red Blood Cells of Man should appear beneath that of Red Blood Cells of the Newt and vice-versa.

Radiation and Wave Motion : The Royal Society at Wembley.

By Thomas Martin, M.Sc.

In response to requests from many readers we give herewith a fuller account of the wealth of experiments demonstrated at the Royal Society's exhibit at Wembley.

THE arrangement of the Science 'Exhibition in the Pavilion of His Majesty's Government at the British Empire Exhibition has again been in the hands of a committee of the Royal Society, this year under the chairmanship of Mr. F. E. Smith, C.B.E., F.R.S.

For the physical section, a definite theme in physical science has been taken, and an attempt has been made to illustrate this in a connected manner by means of exhibits, the majority of which are working experiments. The theme is radiation and wave motion, and as a key exhibit a large chart is shown, setting out on a scale of octaves the complete range of electromagnetic waves as it is known at present, in the form of an extended spectrum.

All Lengths.

Thus, the visible spectrum has been extended beyond the violet end to show the ultra-violet radiations ; and these link on, in order of descending wave-length, to the X-rays and the gamma rays from radium. Again, beyond the red end of the visible spectrum we have the heat radiations of the infra-red region, and it has now been shown that the greatest wavelength known for infra-red rays is slightly longer than the shortest waves generated by electrical means. The spectrum may thus be extended to take in the whole range of Hertzian and wireless waves and even to the slow oscillations, corresponding to very long waves, of ordinary alternating electric current.

In the exhibition the apparatus shown is intended to illustrate the existence and properties, and methods of generation and detection, of radiations in the different regions of this extended spectrum ; and to demonstrate the remarkable conclusion which modern

physical research has reached, namely, that of the essential identity of all these different forms of radiation.

All experimental evidence points now to the fact that visible rays, ultra-violet and X-rays, infra-red and wireless waves, are one and the same thing, having, indeed, widely differing properties and requiring a variety of different methods for their generation and detection, but with this property in common, that they travel always with a uniform velocity, the velocity of light, their varying properties being due simply to differences of wave-length or frequency.

The Atom.

First, however, the atom, as the ultimate source of all radiation, must not be neglected. In the exhibition, by means of small coloured lamps suspended overhead, the atom of neon, with its proton, its inner ring of two and its outer ring of eight electrons, is shown diagrammatically on a very large scale. Models by Professor W. L. Bragg and Mr. D. R. Hartree show, in a striking manner, the positions of the orbits of the electrons in different atoms, and their disposition, for example, in a crystal of rock salt.

Discoveries in radio-activity have led, in the hands of Sir Ernest Rutherford and others, to modern knowledge of the structure of the atom. Some of his original apparatus is shown, together with some of that used by Sir Joseph Thomson in the work which resulted in the discovery of the electron. In this connexion, too, may be seen the apparatus, based on Professor C. T. R. Wilson's cloud-expansion method, making visible the tracks of alpha particles from radium ; with an experiment, shown by Professor Lindemann



DEMONSTRATING CROOKES TUBES TO A VISITING SCHOOL CLASS.

and others, by which the ionizing effect of an alpha particle is amplified and made audible in a loud speaker.

Gamma rays are represented by an experiment provided by the National Physical Laboratory in which the rays from five milligrammes of radium may be shown to penetrate thick masses of lead, brass, and other materials.

Spectroscopic Region.

The section on X-rays includes the striking experiment, arranged by Mr. F. D. Edwards, and based on the historic investigations of Sir William Crookes, by which a high tension electric discharge from an induction coil is passed through a long tube from which the air is gradually exhausted. The succession of beautiful effects may be seen until, when the requisite degree of "hardness" is reached, the cathode rays excite fluorescence on the glass walls of the tube and X-rays are developed. With this exhibit are shown working some of the original Crookes' experiments, including the "Railway" tube, in which a vane wheel is made to travel along the tube by the action of the cathode rays; and a modern X-ray tube, demonstrating one of the important results which have followed from Crookes' early experiments.

With the X-ray exhibits may be seen instruments and models illustrating the work of Sir William Bragg on the investigation of the structure of crystals.

The fluorescence excited by ultra-violet radiation in different materials is shown by the National Physical Laboratory, and is made use of by Sir Herbert Jackson to show its existence in the radiation from a condensed spark between aluminium electrodes. The ultra-violet rays are brought to a focus, which may be seen on a fluorescent screen, by a quartz lens, at a different distance from that of the focus for the visible rays.

On the benches devoted to visible radiations may be seen a number of beautiful spectroscopic and other experiments which space will not allow us to describe in full. Mention must be made, however, of the demonstration from the National Physical Laboratory in which a large image of the visible spectrum, formed by a calcite prism, is projected on to a screen. Here the existence of ultra-violet radiation beyond the violet end of the visible spectrum is shown by means of a fluorescent screen of zinc sulphide, while the heat radiation beyond the red end is demonstrated by means of a Moll thermopile and galvanometer. Elsewhere, typical line and band spectra are shown, including the spectrum of the sun, with the Fraunhofer lines; while other experiments illustrate the interference, diffraction and polarization of light, and the photo-electric effect.

An infra-red spectrometer shows the method used for the observation and measurement of heat radiation of wave-length greater than that of red light.

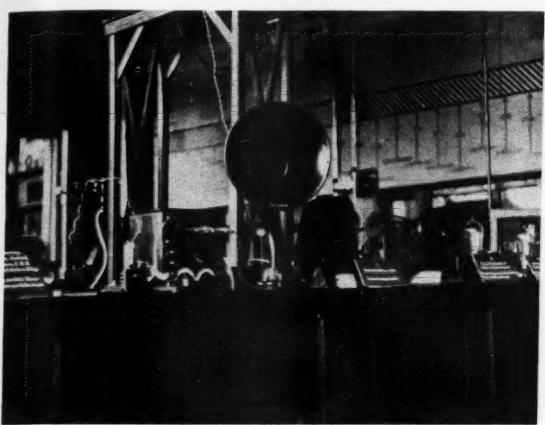
In the section devoted to wireless waves, a number of simple but extremely interesting experiments are designed to illustrate the properties and the methods of generation and detection of the electro-magnetic radiations used in modern wireless. Thus, the National Physical Laboratory show the directional properties of the waves sent out from an oscillating system, which are made use of in wireless direction finding; while the same source of oscillations, by induction in a neighbouring coil, enables the heating effect of the induced currents to be shown with a small glow lamp, and their rectification by means of a crystal rectifier.

The cathode ray oscillograph is an instrument in which use is made of Crookes' discovery that the cathode rays may be deflected by electric or magnetic fields. Applied to the purposes of electrical research, a method is provided whereby the form of the waves generated by high frequency oscillations is actually depicted on the screen of the oscillograph. The National Physical Laboratory show experiments of great interest, in which the method is applied in the determination of radio frequencies, to show interference between two radio frequency waves, and for other purposes.

Wireless Radiations.

Modern wireless is dependent on the thermionic valve for rectifying and detecting, amplifying and generating high frequency oscillations. The valve is the outcome of research following the discovery of the "thermionic effect," that is, the emission of electrons, or negative electricity, from hot bodies. The valve in its simplest and earliest form was a rectifier, and it "rectified" or converted the feeble high frequency oscillations into a uni-directional current, which enabled them to be detected, because of this continuous thermionic flow of negative electricity away from the heated filament. When a metal electrode was sealed through the wall of what was in other respects an ordinary incandescent electric lamp, it was compelled to act as a valve and allow the passage of current in one direction only between the filament and the added electrode, across the intervening vacuous space.

In the exhibition the Research Laboratories of the General Electric Company show a series of experiments designed to illustrate the phenomena of thermionic emission, experiments which should help many to understand the working of the valve; while few can



SEEING AND HEARING THE EFFECTS OF ALPHA PARTICLES.

fail to be interested in the exhibit of the inventor of the valve, Dr. J. A. Fleming. Here may be seen the first valve ever made, the actual incandescent lamp, with a metal wire sealed through the bulb wall, first used by Dr. Fleming in 1904.

Last Words.

It is difficult to believe that no more than twenty years have seen the infancy and growth of modern wireless.

To complete the electro-magnetic range, experiments are shown by the National Physical Laboratory with the low frequency electrical oscillations which are directly audible in a telephone or loud speaker. The loud speaker is arranged to speak into the trumpet of a Low-Hilger audiometer, which gives a visual record of the sounds received by it. Wave form, interference and other phenomena are thus depicted, with this instrument, for oscillations of audio-frequency, just as they are shown on the cathode ray oscilloscope in the exhibit of the National Physical Laboratory, for the higher frequencies.

The physical exhibits thus illustrate, by a series of working experiments, and in a manner probably never before attempted, a conception, that of radiation and wave motion on the electro-magnetic theory, which has clarified and illuminated almost the whole

field of physical science. This theory of radiation, which has its origin in the mathematics of Clerk Maxwell, and which has been developed in the last few decades in innumerable directions, has guided and stimulated physical research to many of its greatest triumphs; and few would care to say that its fertility is yet exhausted.

A New Book.

Description of the other physical exhibits, for example, those relating to geophysics; and of the biological section, which contain a number of interesting exhibits illustrating work in the sciences of botany, zoology, and physiology, must be reserved for another occasion.

In conclusion, readers of DISCOVERY may be interested to know of the book, "Phases of Modern Science," which has been published this year by the Exhibition committee. It contains a series of articles, by distinguished authors, dealing with the aspects of science illustrated at the Exhibition; and includes the handbook to the exhibits. It is obtainable outside the Exhibition from Messrs. A. & F. Denny Ltd., 163a Strand, London, W.C.2, at a cost, including postage, of four shillings.

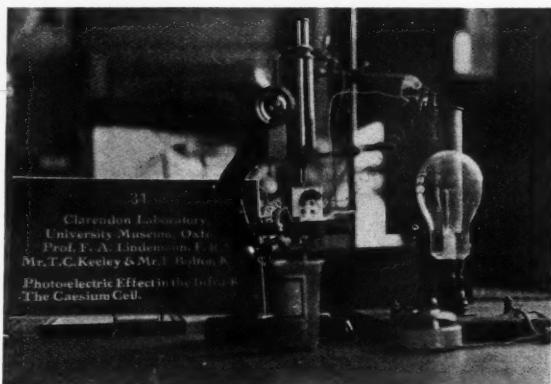
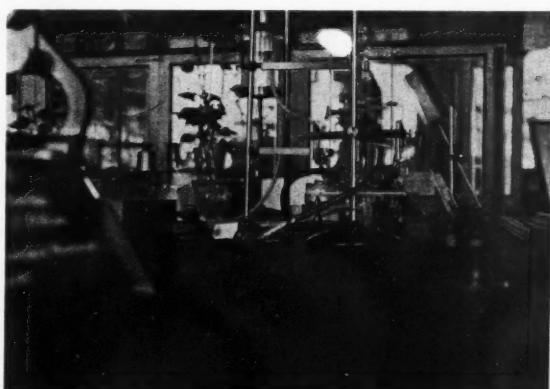


PHOTO-ELECTRIC EXPERIMENTS.



EXPERIMENTS IN PLANT PHYSIOLOGY.

Eminent British Naturalists.

By Thomas Wooddisse.

The Trustees of the British Museum (Natural History) have recently issued a series of postcards of famous naturalists. Many of these men were British, and this short article gives us an idea of their influence as pioneers of scientific thought in their time and discloses their close connection with the growth of the British Museum as we know it to-day.

ADAM, of whom it is written that he gave names to all cattle, to the fowl of the air and to every beast of the field, is not represented in the series of postcards in spite of his claim to be regarded as the father of the science of zoology as well as of all mankind; nor is his descendant, Noah, included, though he is reported to have formed a very notable zoological collection. The Greek philosophers, who included natural history among the subjects to which they devoted their attention, and the mediæval herbalists, as well as the seventeenth century naturalists, are likewise neglected in favour of men of the eighteenth and nineteenth centuries whose work is more closely allied to that being carried on to-day.

Foundations.

Though he is not one of the British naturalists with whom this article is intended especially to deal, mention must, in passing, be made of the great Swede of the middle eighteenth century, Carl Linnaeus. He is not only the earliest as regards date of the naturalists depicted in this set of postcards, but is, from the point of view of the systematic worker, at any rate, the father of both botany and zoology as practised since his time. He established, by the simple expedient of prefixing the name of the genus to that of the species, a system of nomenclature which, in spite of the infinite variety of the organisms to which it continues to be applied, still proves adequate for its purpose. His work, and that of Cuvier, the French zoologist of the early nineteenth century who raised the study of comparative anatomy to

the dignity of a science, form the foundation upon which Banks and Solander, Pennant, Jardine, and Owen afterwards built.

Captain Cook, the earliest of the Englishmen represented in the set of postcards, was properly not a naturalist at all. His fame rests on his achievements as a navigator, a cartographer and an explorer, and his career is too well-known for its details to need repetition here. The inclusion of his portrait is due to his association with the botanists, Sir Joseph Banks and Daniel Solander, who accompanied him on his first voyage round the world, and to one of whose collecting forays on the coast of Australia we owe the name Botany Bay. These men are intimately connected with the history of the British Museum. Solander, who had studied at Upsala under Linnaeus, subsequently became Keeper of

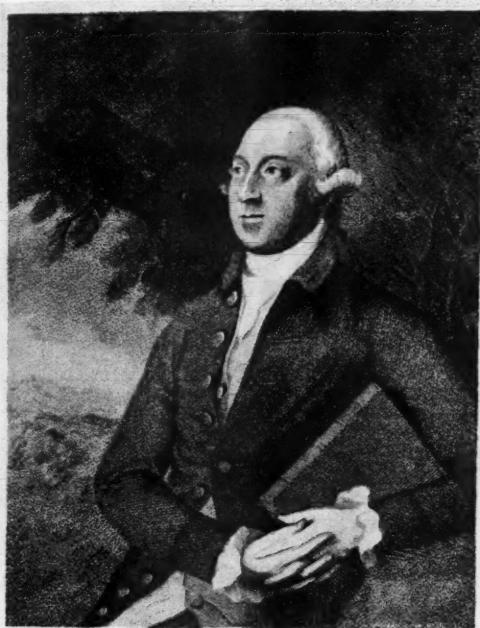
the Natural History Department, and Banks's bequest to the Museum of his collection of plants brought about at a later date the formation of the separate Department of Botany.

Travelling Naturalist.

Thomas Pennant was one of the earliest British zoologists to work on the lines laid down by his older contemporary, Linnaeus. He was a cultured country gentleman and travelled widely, both in Great Britain and on the Continent, his tours in Scotland being particularly famous. He studied, classified, named, and wrote about the mammals and birds which came within his ken, and his books, which displayed in a high degree the power of making dry and technical



CAPTAIN JAMES COOK, F.R.S.
[By permission of the Trustees of the British Museum.]



THOMAS PENNANT, ESQ.
[By permission of the Trustees of the British Museum.]

matter interesting, long remained among the most authoritative works available on these subjects. A collection of original coloured drawings of mammals and birds, made in the East about 1750, and purchased within the past few months for the British Museum (Natural History), are of special interest, since a number of them were reproduced to illustrate Pennant's "Indian Zoology," one of the earliest works on the natural history of that part of the world.

Three Useful Baronets.

Of a similar social class to Pennant were the three Scottish baronets, Sir William Jardine, Sir Roderick Impey Murchison, and Sir Charles Lyell, who were all born within a few years of Pennant's death just before the close of the eighteenth century. Jardine's tastes followed much the same lines as those of Pennant, his principal interest being in ornithology. He was a good shot and an ardent fisherman, and in addition to his devotion to the study of birds, his scientific pursuits included geology and botany. He is important in the history of the literature of nature study, having published "The Naturalists' Library," of the forty volumes of which he was himself responsible for fourteen. He also started "The Magazine of Zoology and Botany," which eventually became "The Annals and Magazine of Natural History," and is still an

important medium for the publication of scientific papers.

Sir Roderick Murchison began life as a soldier, and fought in the Peninsular War. He retired from the army at an early age and assumed the easy life of a man of leisure; but influenced by his wife to take up some serious pursuit, and an enthusiasm for science having been awakened in him by his friend, Sir Humphry Davy, he devoted himself to the study of geology, a science then in its infancy. He travelled and surveyed indefatigably, both in Great Britain and abroad. One of his most notable pieces of work was a geological survey of Russia from the White Sea to the Sea of Azov, carried out in the course of two comparatively short visits to that country. He gave the name Silurian to the strata which he discovered in South Wales, and involved himself in an acrimonious and unnecessary dispute with Sedgwick, who had applied the name Cambrian to the same strata found during a contemporaneous survey in North Wales. He predicted the discovery of gold in Australia, basing his view on the resemblance of the geological structure of the Australian chain to that of the Ural Mountains.

A Field Worker.

Murchison's strong point was his power of rapidly grasping the dominant features in the geology of a district. He had little genius for the development of theory; his great contribution to science consisting

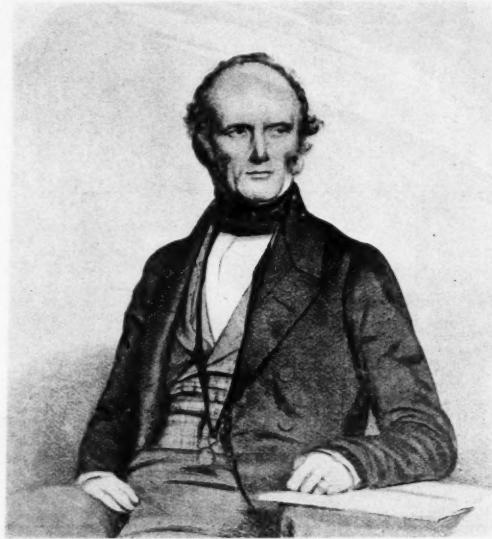


SIR WILLIAM JARDINE, BART.
[By permission of the Trustees of the British Museum.]

in the facts which he observed and recorded. His social influence was considerable, and he was ever ready to exercise it for the benefit of science and scientific workers.

Fresh Theories.

Sir Charles Lyell, like his friend Murchison, was a great traveller and made numerous geological tours in Europe. His success in the pursuit of a science like geology, which depends so much upon the making of observations, is somewhat remarkable in view of the fact that he suffered from extreme short-sight. After William Smith, "the father of British Geology," he probably contributed more than any other man towards the development of the science in its earlier days. He was a very methodical worker and possessed in a high degree the power of drawing sound general conclusions from the evidences at his disposal. The publication of his "Principles of Geology" killed the catastrophic theory of the geological history of the world, and the keynote of the whole of his scientific work was his insistence that the processes of the past must be considered in the light of those now in operation. He was responsible for the division of the Tertiary strata into Eocene, Miocene, and Pliocene, and his "Student's Elements of Geology" was for many years the only convenient geological textbook. For some time he opposed Darwin's theories on evolution, but eventually withdrew his opposition though he perhaps did not fully accept



SIR CHARLES LYELL, BART.

[By permission of the Trustees of the British Museum.]

Darwin's views. Murchison and Lyell were workers in the field of stratigraphical geology rather than in that of palaeontology. They were concerned with the history of the earth itself rather than with the nature and diversity of its extinct inhabitants.

A Great Anatomist.

In so far as Sir Richard Owen was a geologist, he was of the latter type, but he was first and foremost a great anatomist, who in the course of a long and arduous life added vastly to the sum of scientific knowledge of the structure of animals of all classes, both living and extinct. He spent the first thirty years of his working life at the Royal College of Surgeons, at first as Assistant in and Curator of the Museum, and afterwards as Professor of Anatomy. Throughout his life he was better known as Professor Owen than by his knightly title of later years. Here he dissected and described the structure of an immense variety of animals, pouring forth a flood of scientific papers which continued unabated throughout the further period of almost thirty years during which he was Superintendent of the Natural History Departments of the British Museum. Sixty-two years elapsed between the appearance of his first scientific paper and his last, and he produced altogether over 360 such papers, some of them being monographs of the most exhaustive and laborious character. While at the British Museum Owen continued his anatomical researches mainly, in view of the material now to his hand, in the region of osteology, and especially upon



SIR RODERICK MURCHISON, BART.

[By permission of the Trustees of the British Museum.]

fossil bones. His work on the gigantic extinct birds of New Zealand is an interesting example of the kind of research which occupied him during this period. He took a leading share in the storm of opposition which greeted Darwin's promulgation of his theory of evolution, and his attitude in this connection has tended in some measure to obscure the wonderful work he did in his own particular sphere.

A Builder.

In view of the origin of the set of picture postcards which forms the occasion for this article, there is one outcome of Owen's activities which must not be forgotten. When he was appointed to the British Museum, the Natural

History Departments were most inadequately and unsuitably housed in the Bloomsbury building, and

he lost no time in setting on foot an agitation for more worthy accommodation. Undeterred by the Government's decision to provide a mere palliative in the form of an additional gallery at Bloomsbury, he persisted until his scheme for a separate Natural History Museum on a new site was adopted. He was responsible, to a large extent, for the form and arrangement of the present Museum at South Kensington, though he had to surrender to financial considerations on many points, notably as to the provision

Lacking Yet.

of a lecture theatre and of a gallery adequate for the effective exhibition of whales, two needs which are to-day, except for

the small, temporary whale-gallery, still unsatisfied.



SIR RICHARD OWEN.
[By permission of the Trustees of the British Museum.]

A Wolf of the Antarctic.

By J. E. Hamilton, M.Sc., F.R.G.S., F.Z.S.

The author who has sailed on the "R.R.S. Discovery" Expedition in search of scientific data concerning whales, here gives an account of the whale's enemy, the Killer Whale.

ONE of the almost legendary animals of the sea is the Killer Whale.—It appears in many yarns, both verbal and written, as the enemy of the larger Cetacea, and is even credited with forming an alliance with the Thresher Shark in order to overcome the common prey. However sceptical one may feel as to the authenticity of such tales, there is no doubt as to the great ferocity of this creature.

It was the fortune of the present writer to spend about four months of the winter of 1923-24 with the Norwegian whalers on the borders of Antarctica, and during that time he had a Killer Whale collected for scientific purposes. It is possible that the accompanying photographs with a few notes may be of some interest.

In the first place the Killer Whale is the largest of the Dolphins, and exhibits the bold black and white colouration which distinguishes almost every member

of that family. As might be expected from its relationships, it is a powerful and active creature, while its relatively large size enables it successfully to attack many other marine animals.

The specimen examined was twenty-seven feet long and had a notably robust form, the greatest girth being eighteen feet. The clean lines of the body run off sharply to the rather blunt head with its array of powerful teeth which are about forty in number and perhaps two inches long. There are, therefore, about twenty teeth in each jaw, all alike, and well spaced out so that the upper and lower rows interlock completely when the mouth is closed. The eye is small and reddish brown.

Like that of all whales the tail region is flattened from side to side and terminates in a pair of huge horizontal "flukes," but so far as the writer knows the Killer is distinguished from every other whale



THE KILLER WHALE SHOWING THE ENORMOUS PROPELLER-SHAPED TAIL.

by the end of each fluke being sharply bent down so that the tip is vertical, and therefore at right angles to the plane of the rest of the flukes. The very great size of the flippers (which, of course, correspond to the forelegs of a land animal) is another unusual feature—in the specimen illustrated they were six feet eight inches long and four feet wide—the length being nearly one quarter of the length of the whole animal. By contrast the flippers of the huge Sperm Whale are small—in a male of sixty feet they were but four feet

ten inches in length—a little over one-twelfth of the body length. The function of these massive flippers is rather difficult to explain, since the muscles attaching them to the body seem quite useless for turning or flapping them. But it may be suggested that they serve as keels and enable the owner to turn quickly without loss of equilibrium when in pursuit of its prey.

Dorsal Fin Distinctions.

Finally, about the middle of the back there was inserted a fin which was almost exactly symmetrical fore and aft and had a height of some five feet. The great development of this dorsal fin is a feature of the adult male, the corresponding structure of the female being much smaller so that it is easy to pick out the old males in a shoal of Killers.

An examination of the stomach contents showed a surprisingly large quantity of pieces torn from the tongue of one of the larger whales, a process which was

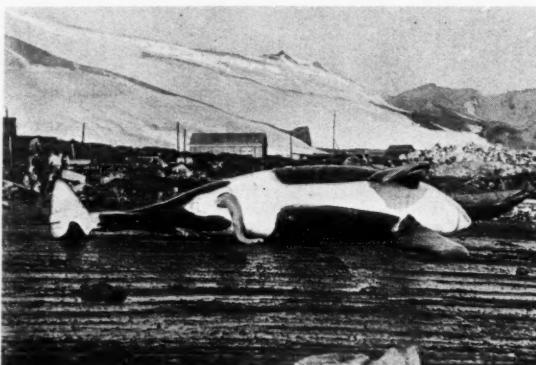
known to have taken place after the larger animal had been killed by the whalers. Besides this there were many hairs of seals, the remains of a considerable number of large squids and an immense concourse of parasitic nematode (round) worms, the whole revolting mass being stained with ink from the squids.

Dangerous Animals.

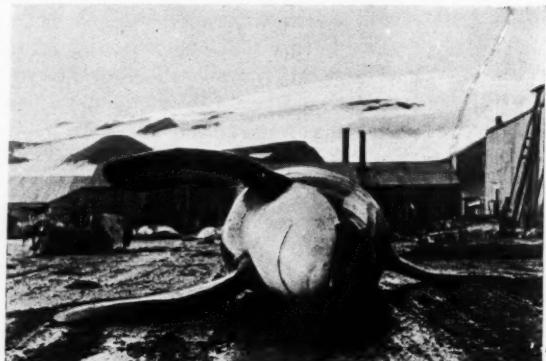
We may turn now to the habits of this interesting creature. It is clearly a carnivore of the most aggressive type and an eater of carrion as well as a killer of living food. Readers of Mr. H. Ponting's "Great White South" and of Captain R. F. Scott's journal of his last voyage, will remember the occasion when the former gentleman was trying to photograph a school of these whales at the edge of the fast ice when the whales started to break up the floe from beneath with the fairly obvious intention of throwing the photographer and two sledge dogs into the water, where they would doubtless have met with a particularly grisly death. Less well known, perhaps, is the battle which took place off the Azores in the 'nineties. The combat arose from a successful attempt on the part of the Prince Albert of Monaco to collect one of three Killers; eventually four boats with

seventeen men were involved, and after an hour another of the whales was killed and the third departed.

In the district where the writer became acquainted



VENTRAL VIEW OF THE KILLER WHALE.



VIEW SHOWING THE ENORMOUS FLIPPERS WHICH WERE 6 FT. 8 IN. LONG IN THIS SPECIMEN.

with it the Killer is common and may at times be seen in shoals of some dozens, although more usually in small groups. After a residence in those waters for some time the whales become discoloured by the microscopic marine plants which settle on their skins. Although these appear to be perfectly harmless, they cause the brilliant black and white to dull to a brown and a yellow, simply on account of their presence in such numbers as to produce a thin film over the whole whale. On account of the apparent difference in colour the Norwegian whalers talk of these discoloured whales as yellow, and of the others as black " Speak-huggers " that is, " blubber-eaters."

As is the case in the Ross Sea Quadrant of Antarctica, in the district under consideration (South Shetland) many of the seals seen are terribly scarred from futile attacks by the voracious Killers.

Whaler's Enemies.

The " Speakhuggers " are detested by the whalers on account of their damaging the larger whales which have been killed for their oil, and are towed alongside the small hunting steamers to the oil extracting factories. The dead whale is towed tail foremost, and since the mouth is usually open, the curiously shapeless tongue hangs out. This gives their opportunity to the Killers who rush up and seizing a mouthful of the tongue " go astern " as they are enabled to do by the remarkable form of the flukes which has been described above. The teeth being sunk deep in the soft tongue a huge junk is soon torn out and bolted—these masses may be one and a half feet square and perhaps six inches thick.

When three or four Killers are making a meal in such heroic fashion, a tongue of many square feet in area is soon disposed of and operations are then directed to the blubber about the head. As a rule the actual loss by Killers is small, but it is the exasperation of seeing any damage done to the whale which has been captured with much labour which is so trying to the whalers. They make many attempts to drive off the hungry monsters with lances and blubber spades, the latter being short blades attached to fifteen or twenty foot larch poles.

As an illustration of the passionate driving impulse of appetite the perfectly authentic statement which follows may be given. A certain factory-manager went for a trip in a whale-catching steamer, and after a long run a whale was killed and made fast alongside. A band of marauding Killers hurried up and assailed the dead whale. The enraged manager seized a lance, and being a powerful man, impaled a Killer with it. In no way

dismayed the whale returned to feed and was greeted with a second lance, after this a boathook and an oar were expended without effect, and the manager was then persuaded to desist from clearing the ship of all movable objects. The Killer must have been mortally wounded, but even then did not lose its thirst for flesh and blood.

The comparison with a wolf intoxicated by the smell and taste of blood is difficult to avoid, so surely the extraordinary savagery of this mammal entitles it to the description of a Wolf of the Antarctic.

SEA ANEMONES.

OUR readers who are at the seaside are reminded of the article on " Sea Anemones," by Dr. T. A. Stephenson, of the Zoological Department, University College, London, which appeared in the April issue. Dr. Stephenson is collecting British sea anemones, and would be grateful for specimens. Full particulars of how to pack and send them are given in the article. Back numbers of the April issue can still be obtained.

SALT AS AN INSECTICIDE.

IT is so seldom that we regard salt as a chemical that it comes as a surprise to learn that the U.S. Department of Agriculture has selected it from forty other chemicals as being the most suitable agent in killing the common barberry. This is a plant that harbours and acts as a carrier for the black stem rust insects that work enormous havoc among cereal crops. Of the forty possible chemicals that were tried only three, salt, sodium arsenate and paraffin were found to be sufficiently cheap, effective and having little harmful effects upon neighbouring plants and grazing animals. Salt was selected from these as it is most easily procured by the average cultivator. By its systematic use it is hoped to wipe out the rusts within a very few years.

MAN AS SEA BEAST—*continued from page 345.*

In many ways a magnetic or gyrostatic compass would be a better balancing organ, but life has never used either the wheel or the magnet. The evolution of the human body resembles that of the British constitution. It is full of relics of the past as curious as the judges' wigs or the city companies, but for most of these vestiges a new function has been evolved.

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The Groma : A Surveying Instrument of the Ancients.

By R. C. Skyring Walters, B.Sc., A.M.I.C.E.

The remains of the roads and aqueducts of the old world show that the ancients had great skill in surveying. Their methods were dependent on their instruments, the principle one used is the subject of this article.

A DISCOVERY by Matteo Della Corte (15*) of great interest to engineers and surveyors has been made at Pompeii, of a surveying instrument used by the Romans and, in all probability, at an earlier date, by the Greeks. The object of this paper is not only to describe this instrument, but also to throw some light on how the surveying and setting out was done by the ancients for the planning and erection of the magnificent aqueducts and other engineering works that they constructed. The instrument was evidently much in use, and its name gave rise to the word "Gromatici," the Roman appellation for Surveyors (1*). It is well known that among ancient civilizations there were some splendid engineers, not the least being those of Greece and Rome, yet little information has come down to us concerning their methods of construction.

Had They Maps?

Nowadays, before such a work as an aqueduct 50 miles long for bringing water to a city like Rome is constructed, a very accurate map of the country must be made by precision-instruments such as the theodolite and level. By the aid of such a map, the best route for the pipe-line or aqueduct may be decided, or, as Hero of Alexandria (3* and 8*) (who lived somewhere between 100 B.C. and A.D. 100) puts it, "the route of the aqueduct must be chosen to avoid a hill which is too steep or ground composed of a stone too hard or too soft, porous, sulphurous or of other nature that affects the quality of water." (A geological map might almost be indicated by these words.) But however difficult it is to conceive how ancient civilizations made maps, it is far more difficult to imagine how sufficient accuracy of measurement was attained as would be necessary in their setting out, *i.e.*, on the construction of such works as aqueducts. In these it would be necessary to build the work accurately both in level and in line not only on the surface, but above the ground on arches and below in tunnels.

It is not proposed to discuss the matter of levelling here, but it will be realised that in this respect the Romans had a far more difficult task than we have in bringing water a long distance to a city; for we can, by the use of iron or concrete pipes, go down one

side of a valley and up another, providing we do not rise above the hydraulic gradient, an imaginary line joining the water levels at the inlet and outlet of the pipe. On the other hand, the ancients, having no pipe to withstand the pressure of water, had to construct their aqueducts to coincide all the way with the hydraulic gradient.

The old Roman aqueduct Marcia, the later Claudia and the modern Pia all carry water to Rome from the same source. Their lengths are respectively 58, 43 and 33 miles. The difference is accounted for by the oldest running along the contours of the hills and parallel with the sides of the valleys, while the second is carried more on arches across the valleys and it had a tunnel three miles long, while the shorter length of Pia is due to the use of iron-pipe. Owing to its greater length, the oldest of these would require the most careful setting out.

The Instrument.

It is, however, with the instrument for alignment that this paper deals; an instrument that will help the human eye to put in pegs in the ground which are in an accurate straight line is one of the fundamental requirements of all setting out and all surveying of engineering construction. For, if a single error of an inch were made in a hundred yards, the line might be nearly 15 feet out of its place in 10 miles, or if a similar error of an inch were made *every* 100 yards, the line would be nearly a quarter of a mile out of its correct position. Another fundamental requirement in both ancient and modern engineering is an instrument that is capable of setting out a straight line at an angle with an existing straight line. An error in the first case of an inch in a hundred yards would certainly not be tolerated nowadays for important work, and it was not tolerated in all probability in ancient times.

Nowadays, the theodolite is used for setting out a line at *any* angle with another line, whereas in ancient days the Romans used the Groma to set out lines at *right* angles only to each other.

Hence, all operations, in measurement of land and setting out, were performed by right-angled triangles, and if the right angles so set out were accurate the work was accurate. Some of these operations will

be referred to again later, and we may now pass on to describe the Pompeian instrument; it may be as well, however, to consider briefly remarks that have come down to us in ancient writings concerning the Groma.

Frontinus in the *Gromatici Veteres* (11*) describes an instrument with a movable plate pivoted on to a stand. At the extremities of two diameters of this plate hang four plumb-lines used to set out right angles.

"To use the instrument, we must steady all the plumb-lines and look at the cords or strings stretched by the weights, setting them in line until the eye sees the nearest only. Then put in the stakes, and having carried the apparatus to the last stake, set it up as before and look at the stakes in the opposite direction by way of a check. Then, to continue the staked-out line when intersected by obstacles, carefully set out the right angles given by the plumb-lines by perpendicular lines at every point of interception."

Again, Hyginus (5*) in describing military works, says:—

"At the entrance of the Headquarters of the staff half way on the main road, there is called the 'Place of the Groma'—railed off because of the crowd which gathers there. The Groma is set up on its iron stand with its plumb-lines in position so that the entrances of the fortification may form the 'star' when the straight lines connecting them are set out. Experts in this art are called Gromatici."

Other information concerning the Groma is given by Schöne (7*), who describes certain remains of an iron upright with four arms that were found in Bavaria, but in view of the Pompeian discovery it appears unlikely that this is an actual Groma, although owing to its resemblance to that depicted on the tombstone (Fig. 1) it is possible it may be one of another type. This is the only illustration of a Groma, carved on a tombstone, that has come down to us. It was found at Ivrea, near Turin (7*). It is a tombstone of a certain Aebutius Faustus, "Mensor," carved in the lifetime of the surveyor, as is indicated by the letters V.F., *vivus fecit*. Both plan and elevation of the instrument—as seems usual with ancient diagrams—are somewhat confused. It is curious that two plumb-bobs only are shown and there is no indication of the "Rostrum" or eccentric arm of the Pompeian Groma.

Hero's Views.

Finally Hero of Alexandria, a very practical man, was evidently well acquainted with the instrument which he calls the "Star," for he says (3* and 8*):—

"I think that those who use this apparatus find serious inconvenience from the plumb-lines not coming to rest quickly, but continuing to swing about for some time, especially with a high wind. This is why some people have tried to use wooden tubes to protect the plumb-lines from the wind. But then the plumb-bobs touch the sides of the cylinders and do not hang truly vertically."

Hero cleverly goes into the mathematical question of the conditions that prevail when (and if) the four cross-arms are not held exactly horizontally; he shows that if the Groma is set up thus, the angles given by the plumb-lines will not be right angles

The so-called Marcus Junius Nipsus, in the *Gromatici Veteres*, in describing how the Groma is used for calculating a distance across a river, says that the ferramentum (*i.e.*, Groma) is set up above a peg, so that the plane (*i.e.*, that which contains the cross-arms) is perfectly horizontal—and the plumb-bob coming from the centre falls on this point (? *i.e.*, the peg). When one is sighting along one of the lines of sight of the instrument one must tap the Groma to make it turn about its centre until in line with the peg placed on the other side of the river.



FIG. 1.—GROMA SHOWN ON A TOMBSTONE FROM IVREA, NEAR TURIN.

The discovery of the Pompeian Groma has made possible the complete reconstruction of this ancient instrument. Hitherto there had been no indication, either in the accounts just quoted or on the tombstone, of how a line of sight could be obtained by an opposite pair of plumb-lines between which was a central stand supporting the whole apparatus. The value of the Pompeian instrument lies in its revealing to us the eccentric arm known as the "Rostrum."

The remains consist of an iron cross with four equal arms, about 18 inches long, at right angles to each other, with four bronze plumb-bobs, three bronze socket pieces, two thin bronze strips (for the "Rostrum") and a stout iron shoe. Associated with these remains was decayed wood.

Reproduction.

M. Della Corte (14* and 15*) has carefully examined the parts, and he has reconstructed the

instrument in a drawing herewith reproduced (Fig. 2). It will be seen that this reconstruction disposes of the difficulty, the interference of the supporting pillar. No such interference occurred because of the horizontal bracket or "Rostrum" which placed the centre of the cross at a distance of about 10 inches from the main pillar; the total height of the latter seems to have been about 6 ft. 9 in. The four plumb-bobs of two different shapes were used in pairs for surveying, one pair representing the "Cardo" or north and south line; and the other pair the "Decumanus" or east and west line.

A full-size model of this Groma is to be seen at the Science Museum, South Kensington.

We may therefore surmise that where the lines connecting gates of old Roman enclosures are at right angles to each other, they have been set out by the Groma. Again we may attribute the proverbial straightness of the Roman road to the use of the Groma. Hero has left a veritable textbook on engineering-surveying, and has given minute geometrical details of the various problems that arise which require to be solved by an efficient instrument for measuring right angles: such as how to set out a line between two invisible points, as would be required for constructing a road, a canal or an aqueduct; or how to set out a line for a tunnel to enable boring to be done simultaneously from both ends to save time in construction, "so that the workmen will meet each other." Several long tunnels for conveying water were constructed in this way, and a resident engineer's account of one such tunnel has come down to us (10* and 14*), in the shape of a report (A.D. 152) of Nonius Datus, hydraulic engineer of the 3rd Legion to the Magistrates of Saldae, Algeria. After meeting with brigands on the way, who stripped him of his clothes and wounded him, he reached Saldae and, after a rest, went to the tunnel accompanied by the Governor. The report continues:—

"I (*i.e.*, Nonius Datus) found everybody sad and despondent. They had given up all hopes that the

two opposite sections of the tunnel would meet because each section had already been excavated beyond the middle of the mountain. As always happens in these cases, the fault was attributed to me, the engineer (*i.e.*, Nonius Datus), as though I had not taken all precautions to insure the success of the work. What could I have done better! For I began by taking the levels of the mountain; I marked most carefully

the axis of the tunnel across the ridge; I drew plans and sections of the whole work, which plans I handed over to Petronius Celer, the Governor of Mauritania; and to take extra precaution, I summoned the contractor and his workmen and began the excavation in their presence with the help of two gangs of experienced veterans, namely, a detachment of marine infantry and a detachment of Alpine troops. What more could I have done?

Blunders.

After four years' absence, expecting every day to hear the good tidings of the arrival of water at Saldae, I arrive; the contractor and his assistants had made blunder upon blunder. In each section of the tunnel they had diverged from the straight line, each towards the right, and had I waited a little longer before coming, Saldae would have possessed *two* tunnels instead of one!"

We are told that Nonius Datus re-surveyed the work and put in a transverse tunnel connecting the two tunnels. This operation must have been skilfully done with the Groma, or some similar instrument.

Finally Hero describes in detail the operation of calculating distances and heights of unapproachable or inaccessible points by means of right-angled triangles such as would be useful, not only in difficult country, but in military operations (13*), "for how often have we come to the foot of the enemy's fortifications with ladders that are too short simply because we had not learnt in peace-time how to find the height of an inaccessible object from our position."

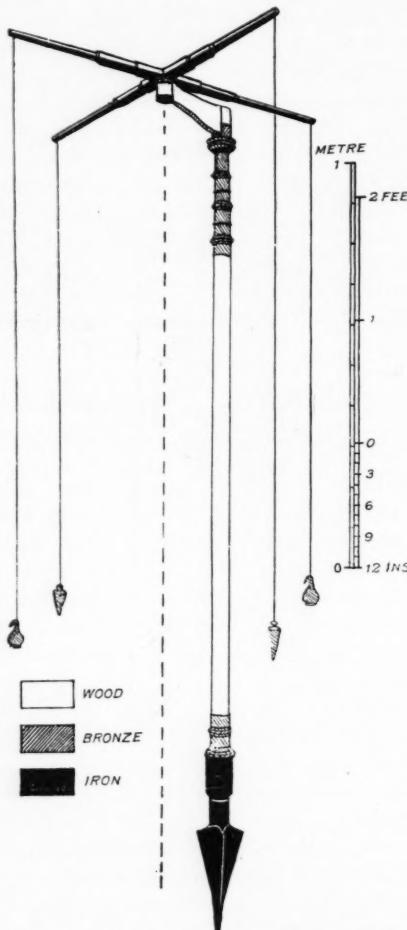


FIG. 2.—DELLA CORTE'S MODEL OF THE GROMA.

He also deals with the measurement of areas, both accessible and inaccessible, the placing of stones for land-boundaries and the calculations involved for replacing a lost boundary-stone, truly the work of the Gromatici Veteres.

The author is much indebted to the Council of the Newcomen Society for the loan of Figs. 1 and 2.

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DIGGING LIQUORICE FOR A LIVING.

THE chief liquorice producing area in China is the Ordos Territory, a steppe lying to the north of the Shensi province. The root is not cultivated, and peasants dig the wild variety under a system that ensures its sale to the Paotih merchant who supplies them with tools. The average price obtained by the peasant under this scheme is from one to threepence per pound. The merchant sorts the roots into nine grades, of which only the two best are exported. The exports of the Ordos Territory during 1923 totalled over ten million pounds, valued at £174,000, and it is estimated that this district finds work for at least 8,000 persons for liquorice digging.

Man as a Sea-Beast.

By J. B. S. Haldane.

When an American calls a Fundamentalist "you poor fish!" he may be using slang, but he has a biological justification for it.

KINGS and editors commonly speak in the first person plural. If we all habitually did so we should understand a good deal more about how we work. For each of us is a community of about a hundred million million cells, whose co-operation is our life. This co-operation is brought about in part by the nervous system, and its beauty and delicacy is apt to blind us to the fact that a great many cells—in fact, the majority—are not supplied with nerve fibres.

Their behaviour is determined by two things, the mechanical and electrical forces exerted on them by their neighbours, and the chemical composition of the fluid that surrounds them or is given to them by their colleagues. How profound is the importance of the non-nervous influences is shown by the fact that the other parts of an embryo develop perfectly before any nerves grow out to them from the brain and spinal cord, and will continue to do so nearly normally, even if the nervous system does not develop at all.

Liquid Surroundings,

If we may use the well-known comparison of the body and the State, we may say that most of our own citizens are not State employees, but act from economic and other motives without any direct orders from the central government. What is more, many of the cells in the brain, the seat of government, are alert to the smallest changes in their chemical environment, and react to them by transmitting orders for some such activity as an increase or decrease of the breathing, which will bring their environment back to normal conditions.

If we observe single cells, such as protozoa, bacteria, or the diatoms and other microscopic plants in sea water, which are the ultimate source of almost all the nourishment of sea beasts, we find that they are often remarkably hard to keep alive. The tiniest changes in the fluid around them, especially in its alkalinity, will kill them or greatly alter their behaviour. Indeed, they are quite as dependent on the presence of the right amount of potassium and calcium salts around them as on that of oxygen or food. As a matter of fact, they spend a great deal of their energy in overcoming the defects of their surroundings. For

example, water almost invariably leaks through the skins of fresh-water protozoa, and they require a special organ, the contractile vacuole, to expel it. Placed in salt water, they only empty this quite rarely to get rid of waste products.

Our own cells are much more efficient than protozoa at their particular functions, but they require an extremely constant and artificial environment. It is the business of various organs, such as the lungs, liver, intestines, kidneys, and thyroid gland, to keep it constant. In the same way a civilized man is generally far more efficient at his particular vocation than a savage, but only on condition that most of his needs are met by bakers, builders, tailors, and so forth. Our internal environment is the blood, or rather its fluid part, the plasma in which the corpuscles are suspended. Some of the activities concerned in its regulation escape our consciousness. If, for instance, the amount of sugar in it becomes too small, the liver makes fresh sugar from a starch-like substance called glycogen, which it contains. If the amount of any soluble constituent becomes too great, the kidneys eliminate the excess. Sometimes, however, our consciousness and will are concerned. A shortage of water leads to thirst; a shortage of sugar, which the liver cannot immediately remedy, to hunger; a shortage of oxygen to panting so intense as to occupy our whole attention and will.

Blood and Sea Water.

The blood plasma of many marine animals is almost the same as sea-water with the addition of a little sugar and other foodstuffs on the way from the gut to the cells, and waste products on the way from the cells to the excretory organs. A cockle's heart will continue to beat if placed in sea-water, though quite a small change in its chemical composition, say, a precipitation of the calcium (lime) salts, would render the sea-water poisonous to it.

We vertebrates have a blood plasma which has much the composition of sea-water diluted with three times its volume of fresh-water. Such a liquid can safely be injected into the human veins in quite large quantities. The chemical agreement is far too good to be a coincidence. Whereas, for example,

all cells contain more potassium than sodium, the plasma contains fifteen times as much sodium as potassium, the corresponding figure for sea-water being twenty-seven. Similarly, the ratio of sodium to calcium is thirty-nine in plasma, twenty-seven in the sea. With regard to magnesium the agreement is not so close. It is suggested that just as the plasma of modern marine invertebrates is very nearly sea-water, so our own represents the sea of a remote period when our marine ancestors first began to develop gills impermeable to its water. Modern

The First Plunge.

fish, even those which live in the sea, have a plasma much like our own in its low salt content, so presumably it was their and our common ancestor that first effectively shut itself off from the sea, possibly by migrating into fresh water.

It is not only our tissue cells that lead this aquatic existence. Most marine animals, both vertebrate and invertebrate, shed their eggs and spermatozoa into the sea, and rely for fertilization on the numbers and swimming power of the latter. We have cut down our output of eggs to one or two a month, but we still continue, in contrast with many insects and crustaceans, to produce spermatozoa which have to swim great distances to their goal, and are therefore required in fantastically large numbers. Their marine ancestry is shown by the fact that they can only live in a fluid containing much the same salts as the plasma. And after our development has started from the fusion of an egg and a spermatozoon, we pass our first nine months as aquatic animals, suspended in and protected by a salty fluid medium.

There are two of our sense organs which bear striking testimony to our marine ancestry. Under the skin of a fish are a number of tiny tubes occasionally opening to the exterior. There is a complicated system on the head, and one on each side of the body, often marked by a conspicuous stripe on the skin above it, as in trout. These tubes contain bunches of microscopic hairs, richly supplied with nerve fibres, and far too delicate to be left on the outer surface of the body. The fish's own movements through the surrounding water, and also local currents and vibrations in the water itself, are communicated to the fluid in the tubes, and bend the hairs over. Thus the fish learns of the speed and rhythm of the water movement in the tubes, as a cat might gauge the strength of a wind by the degree of bending of its whiskers.

Two parts of the tube system on each side of the head are deeply buried in the skull and are highly specialized. One is adapted to respond to fine and

rapid vibrations in the water, in fact, to sounds. The other consists of three loops at right angles, the so-called semi-circular canals. These organs are only connected with the sea by a long narrow tube sometimes closed in the adult. But when the fish turns round, the water in one or more of the semi-circular canals is left behind, like the water in a glass which is suddenly rotated, and presses on the hair cells in the canal. Thus, while the organs in the external system inform the fish of its movements relative to the water round it, those in the semi-circular canals are stimulated by its turning movements.

We land vertebrates have lost most of the fish's canal system, but the two pairs of specialized organs in the head remain as our internal ear, open to the surrounding water in early embryonic life, but closed long before birth or hatching. The eardrum and an elaborate system of tiny bones transmit aerial vibrations to the water in one part of it. The corresponding vibrations of this water act on hair cells at the end of the auditory nerve fibres, and these in turn stimulate those parts of the brain concerned with hearing. When we turn our heads the swirling of the salt water in the semi-circular canals presses on the hair cells. An elaborate system of nerve fibres in the brain links them up to the muscles which move our eyeballs, and as we turn our heads our eyes turn in the opposite direction, so that the direction of our gaze is unaltered. This is a reflex action uncontrollable by the will; in fact, it is impossible to turn one's head suddenly, keeping the eyes fixed relatively to it.

The semi-circular canals can play us false. In a rotating bowl the water gradually comes to rest with regard to the bowl, *i.e.*, takes up the bowl's rate of spin. The same happens to the fluid in our internal ears if we rotate uniformly. Hence the stimulus to the eye muscles ceases, and we can gaze steadily at any object rotating with us; for example, the face of a partner in the pre-war type of waltz, while surrounding objects at rest cannot be fixed. When, however, the bowl or the man stops rotating, the fluid does not, and the eyes execute involuntary movements which lead us to believe that everything is spinning round us. One can also become giddy in a vertical plane by turning round several times with the head bent forward, and thus causing the fluid to swirl in a plane which becomes vertical when the head is raised. The reflex now let loose involves the muscles of the limbs and trunk, and would be appropriate if one were falling over; actually, however it often makes us fall in the opposite direction.

(Continued on page 339).

The Study of Vegetation.

By E. Pickworth Farrow, M.A., D.Sc.

Trinity College, Cambridge.

Many people have never heard of Ecology, the study of plants and animals in relation to their homes and natural surroundings. This article may appeal to many readers of DISCOVERY at home and abroad, for it suggests a little known line of research dependent in the main on observation.

UPON the publication of the writer's recent book on the vegetation of the very dry sandy East Anglian heathland district in Norfolk and Suffolk, known as "Breckland"** the Editor of *DISCOVERY* has asked him to write an article upon the study of vegetation in general, considering it probable that such an article might stimulate readers to undertake similar research work upon any area of natural vegetation—such as heathlands or woods—near which they may live, or which they may frequently visit.

A Pleasant Study.

It is undoubtedly true that this form of research work is very pleasant and fascinating, and that it also has the advantage of taking one into the fresh air and open country amongst the plants and the wild life of Nature in general. These conditions are very favourable for bringing about philosophical speculations concerning the complexity of Nature, and for then producing a very rapid realization that general philosophical considerations are no good, that they had better be left behind, that the actual phenomena of the universe are far too complicated to be dealt with by them, and that the only hope of finding out something generally true lies in careful and critical observational work instead of attempting to evolve the universe entirely from one's own "inner consciousness" as many of the older philosophers used to be so fond of doing. In other words, these conditions are very suitable for producing and developing the scientific spirit and attitude in a person.

Apart from this it is certainly true that many people would be able to make quite interesting, and possibly important, discoveries by careful and prolonged observation of any area of natural or semi-natural vegetation to which they have access. The technical equipment required for this purpose is not at all great. The only trouble is that many people may not know how to begin, and what general attitude to take up towards the matter.

In relation to the two latter points, the writer considers that by far the most important thing to do

** *Plant Life on East Anglian Heaths.* With 23 plates, comprising 46 photographs in the text. Published by the Cambridge University Press, 7s. 6d.

is to retain, develop and employ one's own natural wit and commonsense; also to develop and use one's powers of naked-eye observation and the capacity for forming various types of inferences from these observations; also the power to retain a belief in the results of one's own observations, if the facts seem to justify these, in spite of what the textbooks may say.

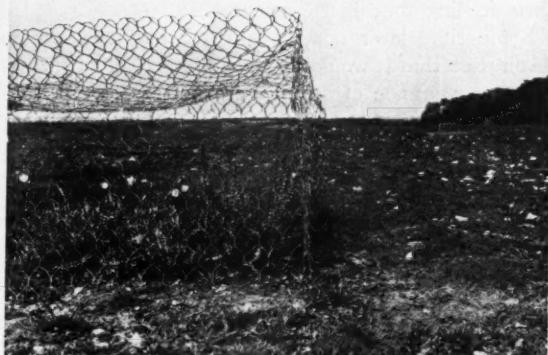
All the above may appear obvious, but the writer feels that they cannot be emphasised too strongly. A certain amount of reading is undoubtedly necessary, but the writer feels that with many people too much reading only serves to cripple their former powers of original observation and initiative, and to cloud their otherwise clear judgment upon the observed facts by tending to bias their views both as to what they should observe and as to the inferences to be drawn therefrom.

If a fresh and fairly wide-awake person commences to study a subject with no knowledge at all of what the books have to say about it, there is always a chance that he may alight upon or observe something fairly fundamental which the authors of the books had entirely missed, and which may ultimately show portions of the books to be unsound or upon wrong lines. On the other hand, if he had read the books first, his original freshness of outlook might have been clouded, he might have received an observational bias from the volumes, and might have been prevented from making his underlying discovery.

Getting down to facts straight away is probably much the best procedure. The results can be checked by reading later, and possibly the mode of working altered thereby, after one has had a bit of original and unbiased experience.

Use Your Eyes.

Thus, upon visiting the area of vegetation which is to be investigated, the great thing to do is to use one's own eyes. Just don't bother overmuch about details at this stage but endeavour to take a broad view of matters, taking as wide a range as possible with the field of mental vision. It would be a good plan to ask oneself the question: "What problem is it, in



CAMPANULA ROTUNDIFOLIA AND YOUNG CALLUNA STEMS INSIDE RABBIT-PROOF CAGE.

the whole of this area, the solution of which would be of the greatest scientific interest and widespread importance?" This question will doubtless remain unanswered at this stage, but the formulation of it will not have done any harm, especially as it will help one to retain as broad an outlook as possible during the progress of the whole of the subsequent detailed research.

A notebook should always be carried when visiting the area, and the investigator should write down in this whatever strikes him, and the observational facts and resulting ideas which seem to him to be of the greatest importance. He will soon want to know the systematic names of many of the plants growing on the area which, if he be a beginner in botany, he may not know; and for this purpose a "Flora" will be required. Probably the best for a beginner is Bentham and Hooker's "Flora," along with the companion handbook, "Illustrations to the British Flora." But a better book really, though it is somewhat more technical, is Hooker's "Students' Flora of the British Islands."

First Lists.

It would be advisable for several days to be spent in this way, going carefully over the area with note-

book and "Flora," carefully noting down anything which strikes one, and endeavouring to formulate general ideas, before any further books on the study of vegetation are consulted. One may note down, for instance, that this heather bush (*Calluna vulgaris*) appears to be very badly nibbled by something, that the same applies to the gorse (*Ulex europaeus*) over yonder, that several poisonous plants such as black nightshade (*Solanum nigrum*) and hemlock (*Conium maculatum*) are present and seem to be flourishing better than most of the other plants. All of these facts (or whichever others the investigator might meet) would be carefully noted down and pondered over.

External Factors.

A little later one may suddenly notice: "Dear me! These young pine trees (*Pinus sylvestris*) and birch seedlings (*Betula alba*) are

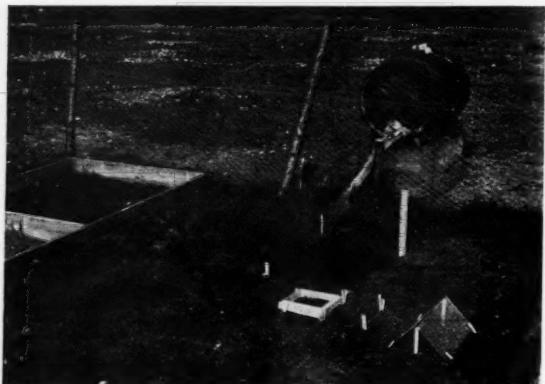
being badly nibbled round the bases of their stems and are nearly killed, probably by rabbits coming from that group of burrows over there." This would be quite an interesting scientific result. It would be an individual case in the particular area of a widespread phenomenon in England, and one which probably costs the country the equivalent of millions of pounds sterling per annum in depriving it of woodland



LARGE MUSHROOM-SHAPED CUPOLA.



CALLUNIS FLOURISHING AND FLOWERING INSIDE A RABBIT-PROOF ENCLOSURE.



LIMITING FACTOR EXPERIMENT ON AVAILABLE WATER SUPPLY OF PROTECTED GRASS HEATH VEGETATION, INSIDE RABBIT-PROOF ENCLOSURE.

timber, a larger supply of which would have been so useful during the Great War. If it had not been for the ravages of rabbits upon the young seedlings many thousands of acres of what are at present sandy trackless wastes in Breckland would have become spontaneously converted into useful pine and birch woodlands. Thus, if we could find some simple method of preventing the ravages, or of destroying the rabbits, a great military and economic advantage would result. This example will serve to show the great mundane importance of apparently abstract researches upon vegetation, apart from their scientific interest. Another worldly advantage lies in the possibility of obtaining hints which may later on indirectly serve to increase the food supply of a country. Some of these considerations apply with special force to certain of our colonial possessions, and certain colonial governments are beginning to realize this, with the result that they are financing researches upon the vegetation of the tracts over which they have jurisdiction.

Watching the Rabbits.

The above remarks are somewhat of a digression, however. We will return to our hypothetical investigator. After having judged the effect of rabbits upon the seedling trees, the unconscious regions of his mind may be gradually turning facts over on their own, and the idea may suddenly rise to consciousness that very likely it was the rabbits which were also biting the heather and gorse plants, and that possibly the reason why the various poisonous plants noticed seemed to be flourishing better than any others was because the rabbits knew—whether from sound instinct or experience—that these did not provide a suitable salad. To check the rabbits nibbling

various plants, it may be considered a good plan to watch them through a pair of prism glasses during their feeding time in the evening.

Some time later our investigator might have the inspiration that it would be a good idea to erect rabbit-proof cages made of strong wire netting let into the ground round some of these plants, and at a sufficient distance round the stems of some of the seedling trees, in order to exclude these grazing influences and be able to see what differences this exclusion produces over various periods of time.

Experimental Controls.

This would certainly be an excellent plan. It is but seldom that we can completely exclude an ecological factor from the environment (the detailed study of plants and animals in their homes is, of course, termed "Ecology" or, more commonly, "Ecology," from the Greek word for "home"). It would also be carrying out an experiment upon the plants in their home which would mark a great advance upon mere observational work. Any results from these experiments would probably be pretty definite, and would apply to the plants directly; whereas the results of soil analyses cannot be applied directly to the plants without the intermediate processes of mental deduction and inference in which lie many possibilities of fallacy and error. Another advantage of starting such experiments is that Nature and the lapse of time achieve



PTERIS GROWING IN RABBIT BURROWS.
Prothallii will not grow on the dry heath.

the results automatically (the results ultimately merely waiting to be recorded) instead of one having to do the laborious work of many chemical analyses with only risky results in the finish. The former fact is particularly satisfactory to a lazy person.

The above notes, based on Breckland experience, are merely examples of what an observer might notice in the early stages of such a research. An investigator working in a different part of the country, or on a different type of vegetation, would of course notice things different from these. Still the above will serve as examples.

Book Fallacies.

It does not seem possible that a Flora used as indicated in the early stages of a research could possibly do any harm in perhaps damaging the unconscious roots of any person's possibly very original ideas. It is not the sort of book which could. In fact, if a certain plant was found growing in a rather damp place and the Flora said it only grew in a very dry place (or *vice-versa*) this would be a very good thing in showing him how unreliable all books are liable to be. Facts are far more fundamental and important than the printed word, and any book can only make a faint attempt at dealing with the highly complicated facts of external reality.

Still it is surprising how very readily and firmly many people will believe, and how strongly they will retain that belief, in anything which they may read in a book.

It seems very likely that this attitude may be a continuation of the general habit of respect for authority forced upon people in their schooldays and continued into the student period at the University, where it is advisable (or at least simpler) to believe implicitly all the books and lectures from the point of view of passing the examinations. In any case the phenomenon is an extremely marked one with most people. The writer well remembers his own very great astonishment when he first began research and discovered that some things stated as facts in certain textbooks were quite erroneous. All scientific books should be read in a highly critical spirit. "Can so-and-so be true? It seems far-fetched to me." "Might not so-and-so be a simpler explanation," etc. All sound authors would wish them to be read with this attitude. With the above qualifications, however, a person, when he had reached the stage in the research indicated above, had certainly better read more about the subject. The two books most useful to him to begin with would probably be "Types of British Vegetation," edited by A. G. Tansley, M.A., F.R.S. (Camb. Uni-

sity Press), and the same author's "Practical Plant Ecology" (Allen & Unwin). The former book may be temporarily out of print but, if so, it could be borrowed from many libraries. The latter book is a very recent one.

From both of these books he will certainly gain much valuable information and many new points of outlook. The latter book in particular will give him many new viewpoints and methods of working—such as mapping vegetation, plant photography, etc.

From the former volume (as well as the present writer's book already referred to) he will gain an idea of the recent realization of the highly dynamic character of natural and semi-natural vegetation—of the rapid manner in which the aspect of the vegetation of a district or country changes as a result of variation in the value of the various environmental factors which affect it.

He will also realize the importance of carefully studying the various transition zones between the different types of vegetation in the succession, and may possibly make maps of certain transition zones with the object of making other maps later on in order to determine the rate at which the various types of vegetation are changing.

Until recently the Americans were greatly ahead of us in this study of vegetational succession (because the facts of succession were presented so very clearly in their large continent) but ideas upon the subject have recently altered rapidly in this country. Our investigator might now, at this stage, possibly be sufficiently interested in the subject to subscribe to the "Journal of Ecology" (Camb. University Press) or he might perhaps care to join the British Ecological Society and obtain the advantages which membership gives*.

Successive Changes.

In Breckland the writer found that, if it were not for the rabbits, the natural highest type of vegetation would be a pine or pine-birch woodland with very little able to grow underneath the trees (except bracken); owing to the ultimately thick surface mantle of deposited pine needles and cones. The rabbits, however, prevent the seedling trees from growing and allow the shorter growing heather to survive.

When the rabbit attack becomes heavier, the heather bushes become eaten down and gradually die, and sand-sedge grows in their place. When the rabbit attack becomes heavier still, the sand-sedge is eaten down and the still more dwarf type of grass heath

* The Secretary, Dr. E. J. Salisbury, The Briars, Radlett, Herts., would be glad to supply full information to anyone desiring same.

has a chance to survive. Under conditions of extremely heavy rabbit attack the surface consists almost solely of bare sand, especially as this process of clearing is facilitated by the wind being able to cause surface sand-blasts when the ground vegetation is already very sparse. We here have a very interesting succession possessing five distinct stages, the existence of each stage being associated with a particular intensity of rabbit attack.

The above is certainly the chief cause of the curious patchwork distribution of vegetation which we frequently find at the present day in Breckland—*i.e.*, the possibility of the existence of a particular type of vegetation upon a particular patch depends upon the existence and maintenance of a particular intensity of rabbit attack upon or over this patch.

How Ideas Come.

Although it is undoubtedly true, the discovery of this "Biotic Zonation of Breckland" came to the writer one night in a dream, after he had been pondering for several days as to what could possibly be the explanation of the apparently reversed and anomalous distributions of the sand-sedge and grass heath respectively in relation to certain particular rabbit burrows amongst *Calluna* heath. Doubtless his mind continued working during the night under the irritation of the problem, but although the irritated consciousness seemed quite incapable of solving it, the deeper portions of the mind could apparently provide the solution when the irritation was temporarily allayed by sleep.

The history of the writer's experiments upon cutting off rabbit attack by wire cages is also of some psychological interest. Admittedly he had the idea that for the purpose of determining whether water-supply was a limiting or controlling factor to the growth of the vegetation of the grass-heath under natural conditions, it would be a much better plan to arrange for a continuous drip of additional water, and see if the vegetation grew taller and better as a result, rather than merely to attempt to deduce this fact in a very unreliable way from determination of the water-content of the natural soil, which was all that had been done previously. It was then clear to him, from his previous observations, that if the irrigated vegetation were going to grow taller as a result, it would be necessary for this experiment to be protected from rabbit attack, as otherwise the rabbits would eat all this extra vegetation down nearly to the low level of the general grass-heath.

This was how the idea of rabbit-proof cages arose—merely in order to protect the water-drip experiment

—and it was solely as a derivative from this necessity that the idea occurred to protect various types of plants in various other positions from rabbit attack and see what happened. Anybody reading the Breckland work might think that it would be an obvious plan which would occur to anybody *ab initio* to erect these wire cages; but apparently the individual human mind does not work this way at all but can only pass from one idea to another by very easy stages. This reminds one of a remark of McDougall's that Darwin seriously overestimated the mental powers of the higher apes on an anthropomorphic basis, and that modern psychological research has shown that the working of the human mind is far nearer that of the ape's than Darwin ever supposed. People generally only see the final result and do not notice the very easy stages by which this final result is attained.

This only emphasises the necessity, or at least the very strong advisability, as the writer has already tried to indicate, of conserving very carefully the small amount of original ability which anyone *does* possess and of directing this ability to the very best purpose by careful arrangement of work and methods of attacking problems. This condition applies particularly to ecological work in which many of the problems are so complicated that they seem quite insoluble at first sight.

Work Slowly.

From the point of view of conserving energy and solving as many problems as possible within a given period, it is undoubtedly the best plan to spend a great deal of time first upon continued general simple observational work, instead of immediately embarking upon detailed and time-absorbing attempts to solve particular individual problems upon the basis of merely preliminary hypotheses. In doing this simple observational work many problems automatically solve themselves, or become solved, by means of the subsequent general observations; whereas if one had attempted to solve these problems at the start by means of a detailed *direct* attack upon them, the subsequent observations show that the original attack would probably have been upon quite wrong lines, that a very great deal of time would have been wasted, and that probably no results of value would have accrued. Two examples of this highly important fact will now be given.

1. When the writer first began the work in Breckland he thought of analysing many samples of the soils under the heather, sand-sedge and grass-heath associations upon the conventional view that the differences in

the vegetation were caused by differences in the soils. These analyses would have taken a great deal of time and various differences in the water-contents, etc., of the different soils would undoubtedly have been detected, but the time would have been wasted. Continued and apparently irrelevant observational work ultimately showed that these differences in the water-contents would have been chiefly due to the occupation of the various areas by different kinds of vegetation owing to the variation in the intensity of the rabbit attack in different places, instead of differences in the vegetation being due to differences in the soils.

Barrier Elements.

2. The writer found an extremely pretty instance of a biotic barrier (*i.e.* a barrier caused by living organisms) to the spread of a species. This was a case in which sand-sedge, spreading rapidly by means of its underground rhizomes, was stopped abruptly by a row of pine trees several yards from the tree trunks whenever the row was fairly continuous; but that the sedge approached narrow gaps between the pines, and wherever any gap was wide enough, the sedge streamed vigorously through. It seemed that this phenomenon, in addition to being so striking, might also possibly have a bearing upon the important question of the relation of a grassland type to forest, and the writer spent a lot of time trying to find out why the sedge was stopped. Many light-intensity determinations along the limiting edge were made in case it might be caused by shading from the trees. The writer also thought of determining the water content of the soil in different places in case drying of the ground by the trees might be the cause. When he thought of the superior experimental method, he thought of arranging water drips along the limiting edge in order to see what happened; but all these ideas fortunately came to naught, at this stage, owing to the pressure of other problems waiting to be solved. It is too long a story to give here; but, through travelling about Breckland in an attempt to solve other problems, the writer eventually found that the stoppage of the sedge was due to the fallen pine needles and cones, though one would never think this from inspection of the original site, owing to this deposit being mixed with so much wind-blown sand.

The above examples show clearly the advisability of long-continued and entirely general observational work. One would probably also never have noticed the interesting fact that the ordinary bracken fern (*Pteris aquilina*) frequently kills its competitors chiefly by means of its fallen-over dead fronds if one had

been occupied in detailed experimental work and soil analyses right from the start.

It will be noted that the grass-heath in Breckland owes its very existence to an extremely injurious influence which nevertheless greatly benefits it because it injures its competitor slightly more.

This fact may be extremely valuable in illustrating clearly some of the probable effects of war and of protective tariffs upon competing human societies. It may be very important, too, for hitherto the effects of protective tariffs have, in England, chiefly been only considered as to whether they do, or do not, exert a detrimental or beneficial effect *per se* without considering *at all* whether they may not injure competing nations, with which we shall probably one day be at war, to a greater extent. In fact it is very probable that a protective tariff round the extensive British Empire would certainly injure competing nations more than it would injure us—owing to restricting the supply of raw materials which they might otherwise be able to obtain in exchange for the imported manufactured goods. It may be thought probable, however, that highly important scientific ideas of this nature have unfortunately but little chance in such a foolish country as England is nowadays, when people mistakenly hide their heads to the clear and obvious fact that we live in a world of violence, owing to their having repressions upon this matter, and where there is so much cant and hypocrisy to catch the votes of short-sighted people.

The observations in Breckland render it probable that the primitive distribution of woodland in England under climatic conditions at all resembling those of the present day was considerably more complete than has sometimes been supposed—in particular that the whole of the chalk downs were probably once covered by trees, and that the tree zone probably extended nearly everywhere except over aquatic formations, up to the tops of the highest mountains, and near the coast exposed to violent sea winds. Thus, when anyone is working at the ecology of the vegetation of any ordinary non-wooded, non-coastal and non-aquatic area of England, it would be advisable for him to realize that it was probably once covered by trees, and probably would be at the present day if it were not for the influence of man and grazing animals.

All this only shows the importance of a very broad outlook, and the above notes should be useful since they are founded upon personal experience. We will now leave our hypothetical investigator, after wishing him the best of luck and hoping that he may make interesting and useful discoveries concerning the plant life of our islands.

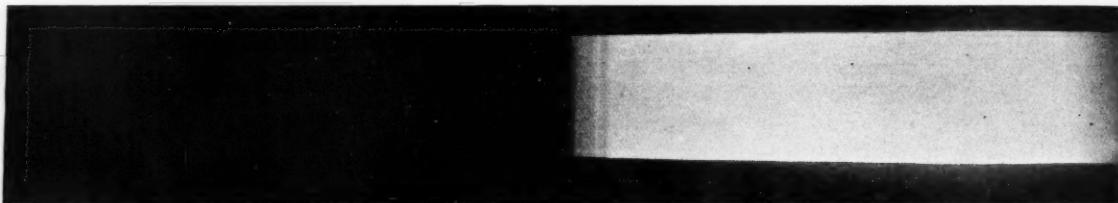
The Unknown Powers of Light.

By Dr. T. Thorne Baker, F.Inst.P., F.R.P.S.

Much is being written about ultra-violet light, but the author, who is one of the leading scientific authorities on spectroscopic work, points out that the medical value of short wave-length vibrations is still largely unknown. It is possible that in the near future we shall learn of discoveries concerning the therapeutic value not of the invisible ultra-violet but of bands in the visible spectrum.

THE very rapid extension of the use of light in medical treatment has revealed the fact that the human subject and many living organisms are very susceptible to wave-length. It is well known, for example, that while ultra-violet light of the longer wave-lengths is valuable for the treatment of rickets and tuberculosis,

after Roentgen's discovery. The beam of X-rays was used for many years quite indiscriminately, with little knowledge of "hard" and "soft" rays, or the fundamental relation between the voltage applied to the tube and the wave-length of the emitted radiation. In the same way to-day we are using



THE SOLAR SPECTRUM PHOTOGRAPHED IN LONDON AT SEA LEVEL.

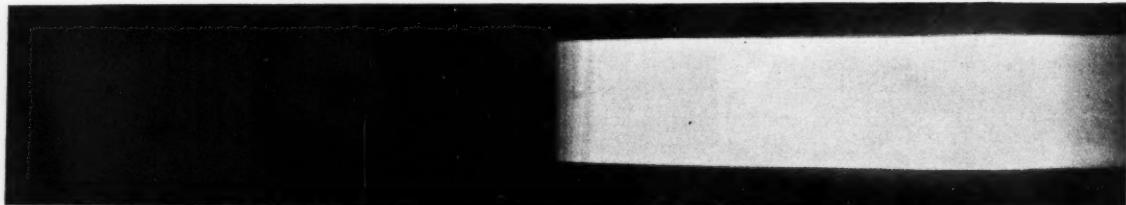


FIG. I.
THE SOLAR SPECTRUM PHOTOGRAPHED ABOVE LONDON FROM AN AEROPLANE 5,000 FEET UP.

the shorter wave-length radiations produce irritation of the skin, erythemas and so on.

Artificial Sunlight.

There is, however, a serious lack of knowledge at present as to the nature of the various types of illumination employed in light therapy. "Artificial sunlight" is being extensively used for light treatment, and is being obtained by the use in most cases of the arc lamp provided with carbon rods cored with metallic salts; these metallic salts enrich the light with ultra-violet rays and are supposed to supply that deficiency of ultra-violet in sunlight which we find in our big towns owing to the absorption of the atmosphere.

Light treatment to-day is in somewhat the same position as X-ray work was for the first ten years

different types of arc and other lamps with an entirely inadequate knowledge of the spectroscopic quality of the light they give, and we may well be running the risk of producing harmful results which will not become apparent until the harm is done.

Altitude Effect.

I have recently taken a number of ultra-violet spectrum photographs of the sun in London, on the ground, and others from aeroplanes flying at an altitude of 5,000 feet. There is practically no difference in the limiting wave-length in the ultra-violet (about 2,900 Ångströms units) in either case (Fig. I) and it is a pure fallacy that Alpine sunshine contains shorter wave-length radiations, i.e., shorter ultra-violet light, than the sunlight of a big city. Miethe and Lehmann,

in fact, showed as far back as 1909 that the position in the solar spectrum of the last trace of action was independent of altitude, and this was later verified by Wigand, who used a photo-electric cell for his measurements and not a photographic method.

Dangerous Unknowns.

If we examine Fig. 2 we shall see that tungsten-cored carbons produce in the electric arc an intense light containing rays of wave-length as short as 2200 Å. The spectrum undoubtedly contains in addition quite intense radiation of still shorter wave-lengths—almost bordering on the very “soft” X-rays—which cannot easily be measured photographically, but the existence of which we know from the work of Lyman and many others.

By one of those simple coincidences in nature the

a vast field for research, and one which will be of immediate benefit to mankind. We have at length become fully alive to the marvellous healing powers of light, and as was seen at the recent International Congress of Radiology, their potentialities are being investigated with energy in all parts of the world.

Some interesting data which have just been published by Mr. J. W. Ryde, of the General Electric Company's Research Laboratory, give us the key to the concoction of real artificial sunlight, and their publication could not have been more opportune. The readiest approach to the sun's rays as filtered through atmosphere is the light of the gas-filled metallic filament lamp—the "half-watt" type. Except for the positive crater of the carbon arc it has a colour temperature most closely approaching that of sunlight, its ultra-violet radiation ends very much in the same



SPECTRUM OF THE IRON ARC. THE SOLAR SPECTRUM ENDS AT 3,000 Å.



FIG. 2.

SPECTRUM OF A TUNGSTEN CORED LAMP SUPPOSED TO REPRODUCE ALPINE SUNSHINE.

ultra violet region in the spectrum of sunshine ends just about where the harmful ultra-violet rays begin—harmful from an irritant point of view, but extremely useful for actino-therapy when used with the necessary medical skill. But to bathe children with "artificial sunshine" by exposing them to the light of an arc such as those shown in Fig. 2 is not to give them sun treatment at all, but "sun" light *plus* an intense far ultra-violet radiation of at present largely unknown qualities. "Sunshine" treatment has often to be strictly limited in time in order to avoid detrimental skin effects, but the spectroscope reveals to us that if we really produced the light of the solar spectrum (Fig. 1) the light bath could be prolonged for any period without harm and *much quicker cures* would be made possible.

Ultra-violet light, in fact, wants filtering just as we filter X-rays for therapeutic work. Here, then, is

region as the sun's, and its large excess of infra-red radiation can be easily filtered out by suitable coloured glass.

Ground for Research.

It must not be inferred from the above that the special arc lamps emitting ultra-violet light, the quartz mercury vapour lamp and so on, have not their uses. We are indeed only on the borderline of knowledge as to the value of the rays of shorter wave-length than 3000 A. Their value in the treatment of disease, the healing of wounds, the sterilization of milk, the inhibition of the growth of bacteria and so on, is barely investigated, and we have as yet hardly attacked an almost equally big problem—the study of the therapeutic value of *visible* light of different colours. Of the latter we are likely to hear much more within the next few years.

The Optical Planetarium at Munich.

A scientific instrument rarely enjoys the popularity of a side-show, yet the Zeiss Planetarium at Munich is attracting crowds of tourists. The instrument is a wonder of mechanical and optical ingenuity, and unlike the old-fashioned Orrery gives the spectator an impression of the celestial phenomena as seen from the earth rather than from an external point in space.

EVER since astronomy began to enter into the sphere of popular knowledge, endeavours have been made to imitate the motions of the earth and moon, and also that of the planets by more or less complicated mechanical devices known as orreries. The very best of these can only furnish a crude imitation of the planetary movements, since radial wires and solid spheres and globules cannot possibly be made to imitate such immense dissimilarities of distance and masses as exist in the solar system alone; neither can the various bodies be made to describe their unimpeded orbits so long as their representative models are supported at the end of radial rods. Moreover, a person following the motions of an orrery is in the position of a living being outside the solar system, to say nothing of the fact that the existence of the fixed stars is necessarily ignored in these purely mechanical orreries. True, a purely mechanical orrery is conceivable, and has indeed been set up in the Deutsches Museum at Munich, in which the spectators take up their stand near the centre of a domed rotunda, along the surface of which the earth and moon are made to travel in their orbits by electro-mechanical means, while a large electric arc lamp at the centre represents the stationary sun of the Copernican system. While this forces the spectator to occupy the position of a solar being, many celestial phenomena, such as the changes of the seasons, the sequence of day and night, the phases of the moon, can be explained more or less adequately.

Change of Method.

Dr. Oskar von Miller, the President of the Deutsches Museum at Munich, shortly before the war commissioned the Zeiss Works at Jena to evolve a large planetarium which would enable the motions of the heavenly bodies to be observed, as seen from the earth. The original idea was to accommodate the spectators at the centre of a large rotunda, the hemispherical dome of which was to represent the starry heavens with the aid of small glowlamps, while the sun, moon, and planets were to be embodied by luminous discs attached to radial rods and moved over the surface of the dome along their correctly imitated orbits.

The very first attacks upon the problem disclosed the hopelessness of any attempt to solve it by purely mechanical means, and soon after the war the project was taken up from a fundamentally different aspect. The hemispherical dome, which in the original scheme must necessarily rotate about an oblique axis conforming to the polar altitude, was now arranged as a fixture and prepared in the manner of a white projection screen, while all fixed stars, the sun, moon, planets, and even the milky way were to be projected thereon, down to the horizon but no further, in strict obedience to their motions by means of a specially computed system of optical projection lanterns.

We may suppose the rotunda to have a diameter of, say, 50 feet (that at Munich is only 33 feet in diameter), its horizon being about 6½ feet above the floor. The multiple projection apparatus with its astronomical motions reaches likewise to the horizon.

Complex Installation.

The projection of the 4,500 fixed stars of the first to sixth magnitude which are shown on the dome proved a comparatively simple matter. In order to obtain a continuous reproduction of the system of fixed stars upon the spherical surface of the dome, thirty-one projection bodies mounted upon a spherical shell of gunmetal with a Nitra lamp of 200 c.p. at its centre and so divided up that thirty-one lantern slides derived from large-scale star maps form a continuous picture. The required spherical shell may be described as an icosahedron, having each of its twelve corners cut off by planes in such a manner that the resulting twenty hexagons and twelve pentagons have identically similar circumscribed circles. The stars are represented by discs of varying diameters according to their size without prejudice to the accustomed starlike appearance. The milky way is projected by means of a number of small lantern attachments giving slightly nebulous images, and a few small projection attachments have been added to indicate the names of the constellations.

The fixed star projector is mounted upon an axis corresponding to the earth's polar axis, so that the projected celestial dome may follow the diurnal motion.

Separate projection heads have been devised for projecting the sun, the moon, and the planets. Any attempt to reproduce, even in rough approximation, the epicyclic orbits of the planets by direct mechanical means has proved impracticable. Recourse was had therefore to the simple Copernican aspect and a mechanism was devised to obtain correct orbits by indirect means.

The arrangement which has been adopted is readily intelligible if we regard the fixed stars as stationary upon a large sphere with a central stationary sun, about which the earth and the other planets move in elliptical orbits. It follows then that the position of a planet as seen from the earth is that point where a line joining the earth and the planet meet the celestial globe.

Planet Paths.

To imitate the relative motions of the earth and a planet, the point which embodies the earth may be supposed to be joined to the point of the planet by a telescoping tube combination capable of adapting itself to changing distances, and further let a small projection apparatus be attached to the end of the extensible tube (or the parallel trellis linkage which is actually employed).

In order that the projectors for the planets may not come in each other's way, it became necessary to arrange them one below the other, in consequence of which the orbit of the earth had to be repeated in conjunction with each of the planets Mercury, Venus, Mars, Jupiter, and Saturn (Uranus and Neptune being omitted from the scheme, since they are purely telescopic objects).

It should be noted that the elliptical orbits of the planets are replaced by circular paths, which is quite permissible, since in the most elliptical orbit of Mercury the minor axis is only 2 per cent. smaller than the major axis. A crank mechanism, however, had to be devised in order to take into account the velocity changes associated with the eccentricity of the orbit.

In the case of Mercury, with its great orbital eccentricity of 0.2, there is still a residual error in the

vectorial angle ranging from -3.9° to $+3.9^\circ$, so that the discrepancy on the projection surface amounts to 6° in the most unfavourable case, viz., when Mercury is nearest the earth. On the other hand, if this compound accelerated motion had not been employed in the place of a uniform elliptical motion the corresponding range of errors would have been $+19^\circ$. In the case of Mars, which comes next to Mercury in eccentricity, these errors amount to only $1/5$ those obtaining in the case of Mercury.

The five planet motions are mounted about an axis which embodies that of the earth's ecliptic and which is capable of being permanently set with respect to the celestial axis. The axis of the ecliptic is set at a permanent angle of 23.5° , with respect to the polar axis. No allowance is made for the minute secular changes due to the slow decline of the obliquity of the ecliptic and the periodic influence of nutation. The effect of precession, on the other hand, was taken into account by applying an additional rotation about the axis of the ecliptic to the entire system of projectors for the fixed stars together with the mechanism for the motions of the sun, moon, and planets.

Sun Projector.

The motion mechanism for the sun projector which is situated immediately below the axis of the ecliptic proved

a simple matter in that the sun's axis could be embodied by a fixed central pin, so that it was necessary only to reproduce the earth's motion.

In the case of the moon a fixed central pin takes the place of the earth's axis, but the reproduction of its orbit presented various complications. In the first place the lunar orbit experiences rather rapid changes, unlike the planetary orbits. Its plane is inclined at an angle of a little more than 5° . This was taken into account by setting the central pin for the lunar orbit at an angle. The small changes in the inclination of the lunar orbit, being periodic, have been ignored. The changes in the direction of the line of intersection of the lunar orbit and the



THE PLANETARIUM PROJECTOR
showing the eccentric mechanism which reproduces the orbits of the planets.

ecliptic, however, in view of the fact that it completes a circle in 18.6 years, was taken into account by applying an additional rotation to the oblique central pin of the lunar orbit. The further disagreeable factor that its major axis turns in the course of every year through an angle of 40° , if taken into account, would have led to an inordinate complication of the mechanism and to great difficulties in the design of the gear mechanism. For this reason the lunar orbit is reproduced by a circular motion, which gives rise to a greatest positional error of about 6° in view of the small eccentricity (0.055) of the lunar orbit.

The phases of the moon are imitated by mounting immediately behind the circular diaphragm which furnishes the projected image of the full moon a small revolving stop. This provides an adequate means of reproducing the phases of the moon within a single period, *i.e.*, from one full moon to the next, but its continued rotation would furnish instead of the phases of the next period their respective mirror images. In order to maintain a continuous motion and to obviate the necessity of an intermittent return to the initial position, the phase projecting attachment has two alternately operating projection heads.

The phases of the planets are not reproduced since they are not naked-eye phenomena.

Speed Transmission.

The whole apparatus is driven by an electric motor mounted at the side of the case iron base. By means of a change gear an astral day can be condensed into $4\frac{1}{2}$ minutes, 2 minutes, or 50 seconds. The motions of sun, moon, and planets are naturally slow against the celestial globe, but by disengaging the motion of the polar axis their motion may be shown at a rapid rate against the stationary fixed-star sky. This motion is furnished by an independent electric motor which is directly geared to the main axis of the planetary mechanism. It can be run at three speeds showing the annual changes in $4\frac{1}{2}$ minutes, 50 seconds, or 7 seconds. The latter speed is mainly provided in order to establish the celestial constellation for any particularized date, past or future, and the motion may be reversed for this purpose.

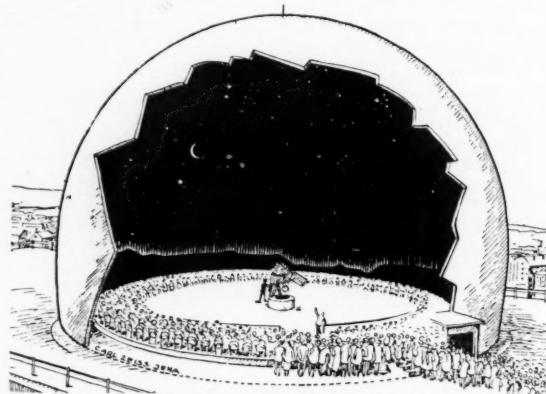
When the annual motion is operating the looplike orbits of the planets stand out clearly. The fixed stars do not appear entirely immobile during this operation, since they experience a very slow rotation about the pole of the ecliptic in consequence of the additional precessional motion.

The whole of the motions are coupled by tooth-wheel gearing, and the accuracy of the motions of the sun, moon, and planets over long periods are determined accordingly by a proper choice of transmission.

The case of Mercury will show how the required train of wheels was arrived at. The driving axis common to all planet motions was given ten revolutions during a sidereal year, so that the transmission ratio of the solar apparatus was 1.10. For Mercury it was accordingly $0.415\ 209\ 106$ which, with the aid of continued fractions, was found to be furnished by the train $\frac{3^3 \times 11 \times 43}{2 \times 7 \times 13^3}$ with a degree of approximation of 10-7. This error would occasion in the case of Mercury a positional error of 1° in 5,000 years.

To reduce friction to a minimum the gear system runs in ball bearings.

By operating jointly the diurnal with the annual driving motions at such a rate that the sun remains



SKETCH OF THE PLANETARIUM
showing the demonstration of the apparatus to an audience.

steadily in its mid-day position, the spectator can be made to see the celestial motions as they would appear to an inhabitant of the earth if it always turned one and the same half to the sun. The orbits of the inner planets are then seen as flat projected ellipses, while the outer planets are seen to traverse the entire zodiac, and the sun executes a periodic up and down movement occasioned in its changing altitudinal positions in summer and winter.

Educational Value.

Quite apart from its value as an astronomical work of precision, there can be no doubt that the installation of an apparatus which condenses the cosmic play of many years into a few minutes, so that the eye may be able to follow and the mind to comprehend the motions of the heavenly bodies as a connected whole, would do much to arouse popular interest in the majesty of the universe. Sun, moon, and planets, visibly coursing across the celestial dome, cannot fail to make a strong appeal to the imagination of the multitude and stimulate its desire for knowledge of things which hitherto were not presented to it in an intelligibly concrete form.

Book Reviews.

Sex and Civilisation. By PAUL BOUSFIELD, M.R.C.S., L.R.C.P. (Kegan Paul. 10s. 6d. 1925).

The status of woman in central Europe has changed rapidly during the last half-century, but the attitude of men and women towards one another has not kept pace with the change; hence the uncomfortable relation of the sexes which seems, from the attention that it attracts, to be more acute now than ever in our history.

Dr. Bousfield sets out to explain the nature of the discord, and to suggest means by which it may be resolved. He puts forward the thesis that the difference between the sexes is far slighter than is commonly supposed, and that it has been magnified, from unconscious motives, both by men and women. He attributes to this artificial exaggeration of sexual difference nearly all the troubles and complexities that sex works in our civilization. He urges that if man will appreciate and overcome the strength of his unconscious wish for male domination, and if woman will deal with her unconscious envy of the male, life might become much simpler and the waste of a great deal of energy might be avoided.

The case is well supported, and although the author seems to write sometimes from the heart rather than the head, and is often a better advocate than judge, yet there is obviously a great deal in his theories and suggested remedy that is very well worth the consideration of everyone who feels that this business of the relationship of men and women has become unnecessarily complicated.

Great stress is laid upon the unconscious personal motives that determine the relations between the sexes, perhaps because they are to-day the most powerful, but there are other, and more general motives, to which Dr. Bousfield does not refer. For example, Crawley has suggested, in "The Mystic Rose," that the differentiation between men and women which is emphasized in many primitive communities and enforced by taboo, has an economic value in ensuring the specialization of men and women in their respective occupations and thereby increasing their efficiency. It may also be pointed out that man's primitive role of hunter, forager and fighter has probably led, by natural selection, to a development of his faculty of imagination—of constructing a picture of the future out of the experiences of the past—while woman, in her primitive role, had less need to look ahead or "seek out witty inventions." This primitive distinction seems to have left its mark upon the mental make-up of men and women, and to have produced a fairly deep-seated if only quantitative, difference between them.

Dr. Bousfield advocates that the differences in name, dress and deportment between the sexes should be swept away and, although such a change is likely to be too drastic for the temper of this generation, it seems less extravagant when we contemplate the approximation of the sexes that has taken place during the last ten years. It is a change to which, curiously enough, Dr. Bousfield does not pay very much attention. He praises woman for discarding the skirt when it interferes with her activities, but he gives man no credit for the increasing skirt-like amplitude of his "plus-fours," nor for his adoption of the jumper; and the suspicion creeps in that the author's ideal of diminishing sexual differentiation entails a great deal of change for woman and very little for man.

An Introduction to Kant's Philosophy. By NORMAN CLARK (Methuen. 10s. 6d. net).

Philosophy is not too popular in these days, mainly because it is so much harder to think clearly than to be a psychologist. Professors of psychology, on the other hand, show inferences in their lectures that the students are supposed to have read Kant. It is not stressed, but perhaps assumed that they found him dull compared to Freud, and those who hold that mind is but a harmonic of the procreative glands.

On the other hand, matured minds and thinkers who have passed their adolescence show a markedly pronounced tendency to "get back to Kant." He is the philosopher whose system most closely approximates to what, for want of a better term, we may call the modern scientific mind. Here we find depth, solidity and thought as durable as granite.

Mr. Norman Clark, who customarily brings an unbiased mind to the problem of whether Boy Simmons of Mile End or Conkey Mendoza of Aldgate East is the better boxer, here hands out an introduction to Kant with all the thoughtful timing and weight of punch behind it we should expect from a judge of the National Sporting Club. He feels a bit shy about this, but it is not necessary. A substantial majority of honest laymen would prefer to have their philosophy selected by a sportsman instead of by some musty don. It is not, improbably, a sounder lead to follow.

The book is, however, perfectly sound and perhaps the clearest exposition of Kant available. There is no waste space and no digression. Point by point he gets at the matter of Kant's system. It is not light reading. Kant was not a superficial thinker, but it is a book which can be heartily recommended to those capable of sustained and critical thought.

Colour Blindness. By MARY COLLINS, M.A. (Kegan Paul. 12s. 6d. net).

Modern chemical methods are increasingly turning toward visual tests, indicators and comparator dyes. Colour blindness, therefore, assumes a position of greater physical importance than before. The old Board of Trade examinations for signalmen to see that they could distinguish a green from a red lamp showed a disconcerting proportion of colour blindness in normal individuals. Dr. Mary Collins has carried out a series of extremely interesting tests which show the possibility of a scale graduation of partially colour blind folk. Her investigations show that though individuals can distinguish red from green, yet when it comes to matching tints partaking of both, many people not suspected of true colour blindness experience difficulties. These people can now be graduated according to a scale of colour disability, and further research discloses the presence of two neutral bands in the spectrum as it is seen by these cases. The book is a valuable contribution to our knowledge of the phenomena of colour blindness and colour vision. Its strength lies primarily in the physiological rather than the psychological aspect. Much of it is complementary of the work of Edridge-Green and confirms much that is already accepted. It is doubtful if the introduction by Dr. James Drever reinforces the value of the book. His rather sweeping claims about the interpretation of Dr. Mary Collins' work may not find ready acceptance among workers familiar with the problem, but should in no case be allowed to distract from the very genuine utility of the book.

Historic Instruments for the Advancement of Science. By R. T. GUNTHER. (Humphrey Milford. Oxford University Press. 2s. 6d. net).

This little book is a handbook to the collections of instruments in the Ashmolean Museum. It deals delightfully with the astrolabes, dials, nocturnals, quadrants, theodolites and microscopes of the past. It is something unusual to hear that Chaucer not only wrote the first English book on the astrolabe to educate his son "Litell Lowis," but that his work is still the standard work on the subject in our language.

The vogue for the collection of early instruments is on the increase, and generous collectors throughout the world will do well to note that the Ashmolean collections will bear reinforcement. The book closes with a plaintive note to the effect: "It is to be hoped that some of the historic microscopes from the fine collection of Sir Frank Crisp may eventually find their way back to the county with which he was so long and pleasantly associated."

One might even go further than this and say that although scientific instruments are well represented at S. Kensington, many of those are dealers' deposits on loan only. The building up of a national collection at Oxford is therefore in no danger of overlapping.

The Sensory Basis and Structure of Knowledge. By HENRY J. WATT, D.Phil. (Methuen. 8s. 6d. net).

In the welter of conflicting schools of psychology, some astonishing theories of "mind" find supporters. Vitalists on the one side fight Ultra-Behaviourists on the other, and as a rule both sets of combatants take their weapons from the physiologists under the impression that they belong to the armoury of psychology.

Dr. Watt's book is a useful corrective, for he brings matters back to solid foundations once more. Sense by sense we are recalled to a re-examination, first of the physiological basis, and then the necessary mental anatomy associated with it to the point of the formation of the concept from the sensation. A clear distinction is drawn between the physiological investigations of industrial psychology as a branch of psycho-physics, and psycho-analysis which is a part of pure psychology.

From the analysis of the single senses we pass from the complex example of stereoscopic vision to the inter action of mind and the mechanism of action to a general scheme of appetitive action and a study of perception, recognition and conception. The outstanding point of the book is the reduction of a wide and not too coherent field to a systematic and orderly progression. The vocabulary is far simpler, and the thinking a great deal more accurate and scientific than is customary with most recent books on psychology. It can be heartily recommended as an introduction to a reasonable and accurate conception of the subject.

Intermediate Light. By R. A. HOUSTON, M.A. (Longmans, Green & Co. 6s. net).

This book will be useful not only to the student for whom it is intended as a textbook, but also to a very wide range of amateurs who require an elementary knowledge of light and optical appliances in general to help them with problems arising out of their hobbies.

The book is well and clearly illustrated, and covers the elements of photometry, lenses, spectra, the eye and colour vision. It is up-to-date and embodies the quantum theory. Question papers and examples are embodied, and the book can be recommended as an admirably concise but adequate little manual.

A Catalogue of British Scientific and Technical Books. Published for the British Science Guild. (A. & F. Denny Ltd. 12s. 6d. net)

A classified list of scientific and technical works is a most valuable volume for specialists and research workers as well as for librarians. This volume follows on the previous publication issued in 1921, and includes 9,515 books. The arrangement under subjects is excellent, for technology is not always easy to classify. Author and title indexes further reinforce the volume and make it a most useful work of reference.

Animal Breeding. By LAURENCE M. WINTER, M.S. (Chapman & Hall. 13s. 6d. net).

The modern farmer bases his success on scientific knowledge. This book is written not for the reactionary but for the modern young farmer with a good education and a grip of elementary science. It is from the University of Saskatchewan, and is typical of the very best of Canadian applied science. Its application is not confined to Canada, but it is useful wherever stock is bred. The scheme is simple: Part I deals with the biological foundation, the cell; Part II with the organs of reproduction, the oestrus cycle, sex gestation and parturition. There is a most interesting section on the why and how of free martins.

Part III covers heredity, inheritance and variations. Mendelism is clearly and coherently explained; in fact, one of the great virtues of the book is its eminently readable style and the clarity with which all facts are progressively marshalled. Part IV is the practice of breeding. An excellent and valuable book to stock raisers all over the world.

Meteors. By PROFESSOR CHARLES P. OLIVER. (Bailliere, Tindall & Cox. 15s. net).

Meteoric astronomy is one of the most interesting branches for amateur workers, for it requires observation rather than expensive equipment. Dr. Oliver's book is comprehensive and affords a good general grasp of the subject for the general reader. The mathematical sections are not difficult, nor, indeed, are they essential to those who wish simply to dip into the subject and eschew figures. The question of stationary radiant points is still controversial, and there are equally well qualified experts who do not agree with Dr. Oliver's views that they do not exist. The Leonids, Perseids, and other chief showers are discussed and a good historical summary and a chapter on methods of observation adds to the practical value of the book. The nature of meteorites from the chemical side and the phenomenon of the ionised track or trail left behind them are somewhat scantly treated in comparison with the wealth of astronomical material. The book is, however, a valuable contribution to the subject, and brings together a great deal of otherwise scattered facts. It is well indexed and adequately referenced.

H. M. W.

Food Values. By MARGARET MCKILLOP, M.A., M.B.E. (Routledge. 3s. 6d. net).

Food is a scientific as well as a domestic problem, and this is a work which treats sternly of calories and vitamins and ignores the cookery of food as an art.

As a scientific handbook for the dietician it can be commended, but it is not too easy to understand if you are a housewife with only intermediate scientific training. There is sound sense about vitamins, an amusing chapter on the Brown Bread Controversy, and many excellent tables of calory values. From a lay point of view it would be improved by a "housekeeper's summary" indicating seasonal choice of foods and the wisest selection of specimen menus to suit different types, from the growing schoolboy to the sedentary worker.

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